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KARNATAKA TEXT BOOK SOCIETY (R.)
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PREFACE

The Textbook Society, Karnataka has been engaged in producing new textbooks according to the new syllabi which in turn are designed on NCF – 2005 since June 2010. Textbooks are prepared in 12 languages; seven of them serve as the media of instruction. From standard 1 to 4 there is the EVS, mathematics and 5th to 10th there are three core subjects namely mathematics, science and social science.

NCF – 2005 has a number of special features and they are:

- connecting knowledge to life activities
- learning to shift from rote methods
- enriching the curriculum beyond textbooks
- learning experiences for the construction of knowledge
- making examinations flexible and integrating them with classroom experiences
- caring concerns within the democratic policy of the country
- making education relevant to the present and future needs.
- softening the subject boundaries- integrated knowledge and the joy of learning.
- the child is the constructor of knowledge

The new books are produced based on three fundamental approaches namely.

Constructive approach, Spiral Approach and Integrated approach

The learner is encouraged to think, engage in activities, master skills and competencies. The materials presented in these books are integrated with values. The new books are not examination oriented in their nature. On the other hand they help the learner in the all round development of his/her personality, thus help him/her become a healthy member of a healthy society and a productive citizen of this great country, India.

We live in an age of science and technology. During the past five decades man has achieved great things and realized his dreams and reached pinnacle of glory. He has produced everything to make life comfortable. In the same way he has given himself to pleasures and reached the stage in which he seems to have forgotten basic sciences. We hope that at least a good number of young learners take to science in higher studies and become leading scientists and contribute their share to the existing stock of knowledge in order to make life prosperous.

Ample opportunity has been given to learners to think, read, discuss and learn on their own with very little help from teachers. Learning is expected to be activity centered with the learners doing experiments, assignments and projects.Textbooks for students X have a special significance. As any other new textbook they help learners' master skills and competencies and at the same time there is going to be a public examination based on them.

The Textbook Society expresses grateful thanks to the chairpersons, writers, scrutinisers, artists, staff of DIETs and CTEs and the members of the Editorial Board and printers in helping the Text Book Society in producing these textbooks.

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FOREWORD

The present Text book of Science for Tenth standard, has been prepared in accordance with the syllabus prescribed under NCF-2005. The constructivism approach that was followed in the Eighth standard and Ninth standard Science text books has been continued in the Tenth standard text book also.

It is imperative that the main aim of secondary education is to provide a firm foundation to the students pursuing higher education. A student entering the tenth standard is expected to acquire sufficient knowledge and develop certain skills which enable the learner to successfully pursue higher education in any discipline. All attempts have been made in this text book to make it student-friendly. The various essential concepts related to the syllabus in science, have been presented in simple and lucid manner. Importance has been given to activity based approach. Ample diagrams, illustrations and examples have been provided to supplement the information. Additional information has been provided in boxes.

We the chairpersons of the text book preparation committee, wish to express our sincere thanks to Prof.G.S.Mudambadithaya, chief co-ordinator, Curriculum revision and text book preparation, for the guidance provided during the preparation of the text book. We also wish to express our thanks to writers, scrutinizers, translators and artists for their valuable contributions. Our thanks are also due to the members of the editorial committee for their valuable inputs which have enhanced the quality of the text book. We also acknowledge the authorities of Karnataka text book society for their kind cooperation.

We earnestly hope that the text book meets the needs of students and teachers. Suggestions for improvement are welcome.

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CHAPTER 1

ALTERNATE SOURCES OF ENERGY

After studying this chapter you

- know about the need for alternative sources of energy.
- learn the various sources of non conventional energy.
- realize the vast potential of harnessing solar energy.
- know other sources of renewable energy.

In your previous classes you have learnt that the sources of energy are depleting and that there is a need for their conservation. Is it just enough if we think of some measures of conserving energy sources such as fossil fuels? Are such measures going to be effective? Should we not think of alternative sources of energy? Yes, the need of the day is to look for alternative sources of energy. Are there any such alternative source of energy?

The social, economic and scientific development of a country are directly linked to its energy resources. The conventional sources of energy that are being used for a long time, are generally non renewable. They include coal, petroleum, natural gas and electricity. We are using them so extensively that their reserves are depleting at a fast rate. At the same time, it is becoming increasingly difficult to discover new deposits. Keeping this in mind, there are attempts all over the world to tap alternative sources of energy.

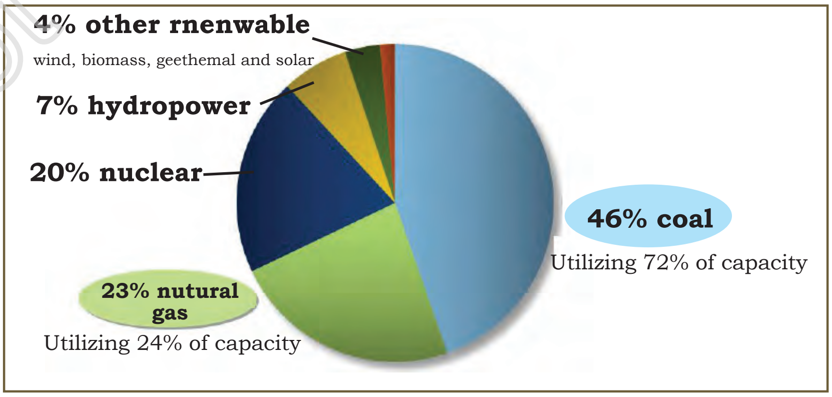

Fig. 1.1 Percentage global use of different sources of energy

Which other sources of energy are being used now? (fig 1.1) At present, there are several sources of renewable energy which are being tapped. These are commonly described as **non-conventional sources of energy**. They include energy from sun, wind, tides, geothermal sources, biomass and even from wastes. These forms of energy are abundant, renewable, pollution free and ecofriendly. They can also be conveniently made available in urban, rural and even remote areas. Use of non-conventional forms of energy can serve two purposes.

- supply of energy in a decentralized system.
- sustaining a cleaner environment.

Let us now look into these alternative sources of energy.

Solar Energy

Sun provides us enormous amount of energy in the form of solar radiation. It reaches the Earth from a distance of about 150 million kilometers, in the form of small wave packets called **photons.** It is the result of continuous thermonuclear fusion taking place in the sun.

Know this

The amount of solar energy reaching per square meter of Earth's atmosphere is called **solar constant.** *It is equivalent to 1.36 kw in 12 hours of time. Energy being received in the atmosphere is about* 1.5×10^{18} *kwh per day.*

Application of solar energy has the following processes

1. Conversion of solar energy into heat energy

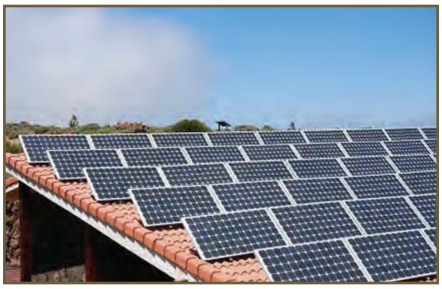

Fig. 1.2 Solar collectors

Solar energy falling on the surface of the earth can be converted into thermal energy. The heat generated can be stored in **solar collectors**. It can be utilized for various purposes such as heating of water and cooking of food. You are familiar with the solar water heaters erected on the roof tops of houses. Solar heaters are also being used in drying of food grains and vegetables, seasoning of wood and desalination of marine water.

Solar Pond

- *Solar Pond is one of the most promising technology in harnessing solar energy. It is a large scale solar collector with an integrated arrangement for storage of heat energy.*

You know that water and air become lighter and rise above, when heated. When water is heated by solar radiation, hot water from the bottom of the pond rises and reaches the surface. It loses the heat gained, to the atmosphere. The result is that pond water remains at a temperature nearer to that of the atmosphere. This loss of heat is prevented by dissolving salts in the bottom of the pond. It makes water denser and hence, it cannot rise to the surface. Thus, solar energy remains trapped in the pond.

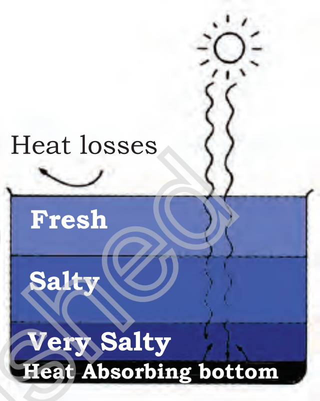

Fig. 1.3 Solar pond

- *India was the first Asian country to have established a solar pond in Bhuj, in Gujarat. It is designed to supply about 220 lakh kwh of thermal energy annually.*

2. Conversion of solar energy into electrical energy.

This requires the use of some solid state materials. It uses the principle of **photo voltaic effect**. Such a device is called **solar cell**. You have seen such solar cells being used in the traffic signals in cities, lighting lamps and pumping water and for other purposes in rural areas.

Bio energy

It includes those processes where biological matter such as plants and plant products provide the basis for energy and its conversion. Plant, organic matter, also called **vegetable biomass,** offers clean fuel for energy. It maintains an unpolluted environment and reduces the carbondioxide content in the atmosphere. Biomass improves quality and water retention capacity of the soil.

Know this

Biogas

Biogas is a clean, unpolluted and inexpensive source of energy for rural areas. It contains nearly 70% of methane, an inflammable gas. It is produced from cowdung in a specific **biogas plant** *commonly called* **gobar gas** *plant. It helps in obtaining both cooking fuel and enriched manure. It can also be used for lighting and running small engines.*

Know this

How is biomass converted into ener

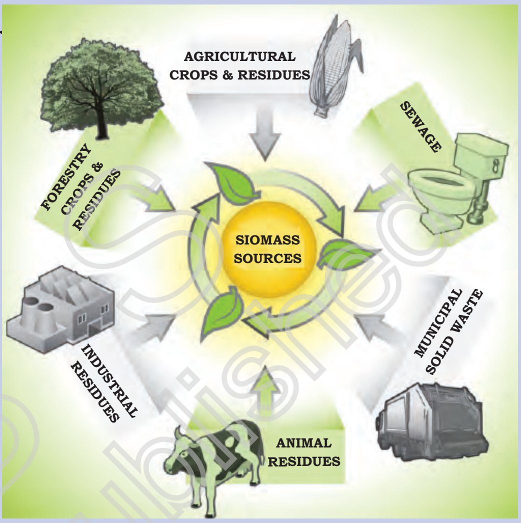

Fig. 1.4 Sources of biomass

There are three basic processes involved in the conversion of biomass into energy sources.

*1. **Combustion pyrolysis :** It is a process of chemical decomposition at high temperature (as high as 5000^0c) in total or partial absence of air. It yields fuel gas, ethanol and charcoal.*

*2. **Bio gasification :** It is a process of anaerobic digestion of biomass to produce a combustible gas called **biogas**, containing methane and hydrogen.*

*3. **Fermentation :** Conversion of sugars into alcohol to produce ethane and solid residual fuel.*

Bio alternative to diesel

The oil extracted from the seeds of the plant, *Jatropha* is now being used as a bio alternative to diesel. It requires the conversion of crude oil from the seeds to a commercially useful fuel. This process called **trans esterification** has been standardised by the scientists at Indian Institute of Science Bengaluru.

Jatropha is a hard plant which can grow on any type of soil, under any kind of agro-climatic conditions. The plant can easily be propagated through seeds or stem cuttings. It grows very fast. Moreover, it is not grazed by animals even during periods of drought.

Pongamia pinnata (Honge) is another plant that yields biofuel.

Know this

Government of Karnataka has a scheme to encourage farmers to grow Jatropha in their field during lean periods of agriculture. The seeds of the plant are purchased by the government, to extract oil.

Biodiesel obtained from such sources is being used to run transport vehicles. The state government owned buses are now using biodiesel.

Activity 1.1

Collect information about other plants which can be used for obtaining alternatives to diesel.

The other forms of renewable energy are wind energy, tidal energy and ocean energy.

Wind energy

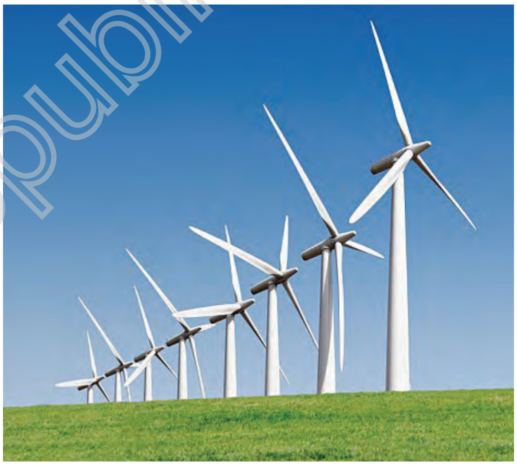

Fig. 1.5 Wind mills

Wind energy is the kinetic energy associated with the movement of large masses of air, resulting from the differential heating of atmosphere by the sun. Hence, wind energy is a converted form of solar energy. The total potential of wind energy is very large. It varies not only from region to region, but also in the same region from time to time. For the utilization of wind energy, ideally the speed of wind should be between 8 and 22 m per sec. Wind turbines are used for the purposes of obtaining **wind energy**. (Fig1.5).

The largest installation of wind turbines in the country are found near Kanya Kumari in Tamil Nadu.

Wave energy

Movement of large quantities of water up and down in the seas and oceans, in the form of **waves** is also a source of energy. This energy can be converted into mechanical energy and electrical energy. The tropical coastline of our country, especially the south west coast line, is found to be highly suitable for establishing energy conversion plants. However, the cost of energy conversion per unit, is very high, since it requires many special equipments to be created near the sea. Wave energy is however more reliable than wind energy since the fluctuations are comparatively less pronounced.

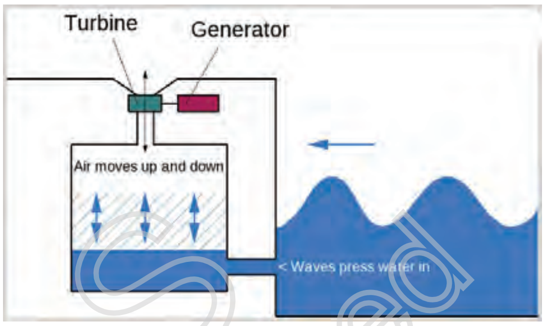

Fig. 1.6 Conversion of wave energy

Geothermal energy

It refers to heat of the Earth within 10 km. from the surface. It can also be processed for power. Geothermal energy has a temperature of about 1300^0 C

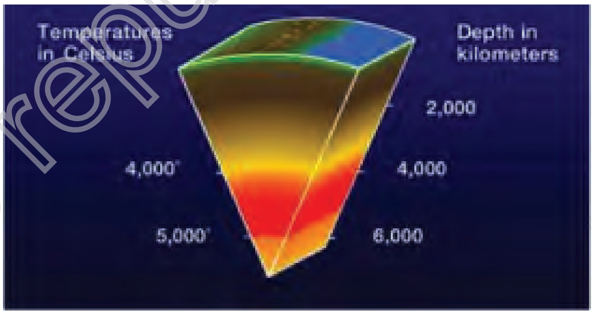

Fig. 1.7 Temperatures in the Earth

There are about 340 hot springs identified in different parts of our country. Of these, only a few have been used. There have been attempts to utilize the geothermal energy in Puga, Manikaran, Tatapani and Bakneshwar. Puga in Ladakh and Tatapani in Madhya Pradesh are most promising.

Energy from wastes

A huge quantity of waste is generated in our towns and cities. Waste generation is very high, especially in sugar, paper and pulp industries. Such wastes can also be converted into energy.

Thus, in the recent years search for alternative sources of energy has yielded good results. If they are properly put into use, we can be self sufficient and can look towards sustainable development.

EXERCISE

I. Choose the correct answer from those given, for the following questions

1. Identify from the following, a conventional source of energy

   a. solar energy b. tidal energy

   c. natural gas d. bio energy

2. The largest installation of wind turbines in our country is in

   a. Ladakh b. Gujarat

   c. Kanyakumari d. Madhya Pradesh

3. Which of the following is not a feature of bio energy?

   a. it improves soil quality

   b. it enhances water retention

   c. it reduces carbon dioxide content in the atmosphere

   d. it increases pollution

4. Which of the following is an indirect form of solar energy?

   a. tidal energy b. energy from wastes

   c. geothermal energy d. electricity

II. Fill in the blanks with suitable words.

1. The principle involved in the conversion of solar energy into electrical energy is called _______________ .

2. The conversion of crude oil from plant seeds into a useful fuel involves a process called ______________.

3. Wind energy is a converted form of _________________ .

4. The energy trapped within 10 km. of Earth's crust is known as_______________ .

III. Answer the following questions.

1. What is the need for exploring alternative sources of energy?
2. Make a list of the advantages of non conventional sources of energy.
3. Differentiate between solar collectors and solar cells.
4. What is bio energy?
5. Name any two plants that are sources of biofuel.
6. Write a brief note on geothermal energy.

* * *

CHAPTER 2

ENVIRONMENTAL ISSUES

After studying this chapter you

- define pollution.
- distinguish different types of pollutants.
- learn about the sources of air, water and land pollution.
- know about the effects of pollutants.
- understand global environmental problems.
- understand the consequences of noise and radioactive pollution.

You are aware that atmosphere, hydrosphere and to some extent lithosphere are parts of the earth from which all the members of biosphere obtain their essential requirements. You also know that the components in these parts, through their interdependence and mutual influence, have maintained a balance in nature. Any change in the characteristics of atmosphere, hydrosphere and lithosphere will have a significant influence on the biosphere, affecting all organisms including ourselves. Today, several human activities have been interfering with the environment, causing serious problems, both at local and global levels. Let us look into some of the major environmental issues.

We have been releasing into the environment, various kinds of substances that are byproducts of our own activities, causing significant changes. Any such undesirable change in the physical, chemical and biological characteristics of the environment, is called **pollution**. Such substances which bring about undesirable changes are called **pollutants**.

Know this

Human interference is a necessary factor to call any substance as a pollutant. For example, oxides of nitrogen released during lightning do not become pollutants, while such oxides introduced into atmosphere by industrial and automobile exhausts become pollutants.

Pollutants are broadly classified into two categories.

Some pollutants can be rendered harmless either by quick dilution to a very low concentration or by conversion into harmless compounds. For example, sulphur dioxide liberated by combustion of coal will get dissolved in rain water and become diluted. Sewage produced in cities can be rendered harmless by suitable biological treatment. The effects of such pollutants remain in the environment only till such conversion. Such pollutants are called **temporary pollutants**. Those that can be degraded by biological activity are called **biodegradable pollutants**.

Most of the pollutants remain as a residue in the environment for a long time and may increase in concentration. For example, lead vapours released from diesel combustion, when inhaled accumulate in the lungs over a period of time. Similarly, a pond near an agriculture farm can accumulate insecticides like DDT. Such pollutants which cannot be converted into harmless constituents are called **non biodegradable pollutants**.

Know this

*Non biodegradable pollutants can enter the food chain where at each trophic level, their concentration keeps increasing. This phenomenon is called **biomagnification.***

Air Pollution

We have been hearing about serious global environmental problems like acid rain, global warming, depletion of ozone layer and climate change. All such problems have arisen as longterm effects of air pollution. Any human activity that brings about significant changes in the atmosphere is called **air pollution**. Following major human activities are mainly responsible for air pollution.

- **Coal combustion:** Several industries use coal as the major source of fuel in their furnaces. Coal combustion releases sulphur dioxide, carbon monoxide and small amount of carbon dioxide, all of which function as **air pollutants.**

- **Diesel combustion:** Diesel is used as a fuel in heavy duty automobiles as well as public transport vehicles. Carbon monoxide and carbon dust are the main pollutants from diesel combustion.

- **Petrol combustion:** Petrol used as fuel in motor cars and two wheelers, on combustion releases oxides of nitrogen, carbon dioxide and lead vapours.

- **Smoking of tobacco:** Smoking of tobacco in various forms can also be a source of air pollution, apart from being a health hazard. Cigarette smoke has a high content of carbon monoxide.

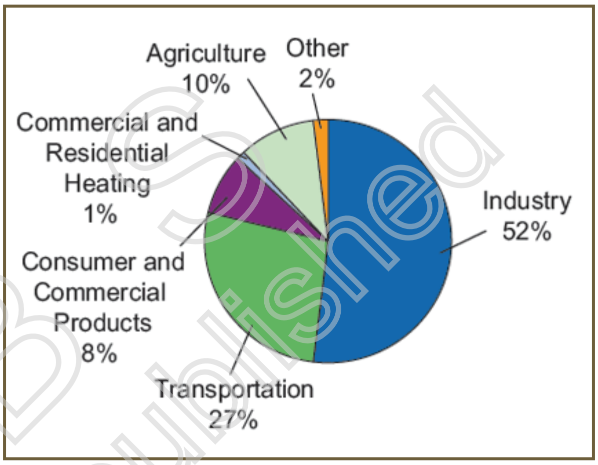

Fig. 2.1 Common sources of air pollution

Know this

Smoking about two packs of cigarette in a day is the same as living in a highly air polluted city for a day.

- **Waste incineration:** The common practice of disposing municipal wastes (garbage) by burning them, is also a source of carbon monoxide.

Know this

We usually think of air pollution as an outdoor phenomenon. However, every one of us, spend nearly three-fourths of our time indoor. During this period, we are constantly exposed to indoor air pollutants. Many of our regular activities from cooking to cleaning, make use of items that are sources of air pollution. This apart, there are many other sources of air pollutants in and around our houses.

Find them by studying Fig. 2.2.

Table 1.1 Common air pollutants and their effects.

POLLUTANT	SOURCES	EFFECTS on HEALTH
Sulphur oxides, Particulates	Coal and oil power plants Oil refineries, smelters, Kerosene stoves	Bronchial diseases
Carbon monoxide	Motor vehicle emissions Fossil fuel burning	Asphyxia leading to heart and nervous system damage, death
Oxides of nitrogen(N_xO_x)	Automobile emissions Fossil fuel, power plants, Oil refineries	Respiratory disorders
Ozone (O_3)	Ozone generators Aircraft cabins	Respiratory disorder
Polycyclic aromatic hydrocarbons	Diesel exhaust Cigarette smoke Stove smoke	Lung Cancer
Asbestos	Asbestos mines and mills Insulation Building materials	Lung cancer Asbestosis
Arsenic	Copper smelters Cigarette smoke	Lung cancer
Allergens	Pollen Animal dander House dust	Asthma, running nose

Control of air pollution

Only a thorough understanding of the causes can help us in taking measures to control air pollution. However, broadly the following measures can be considered.

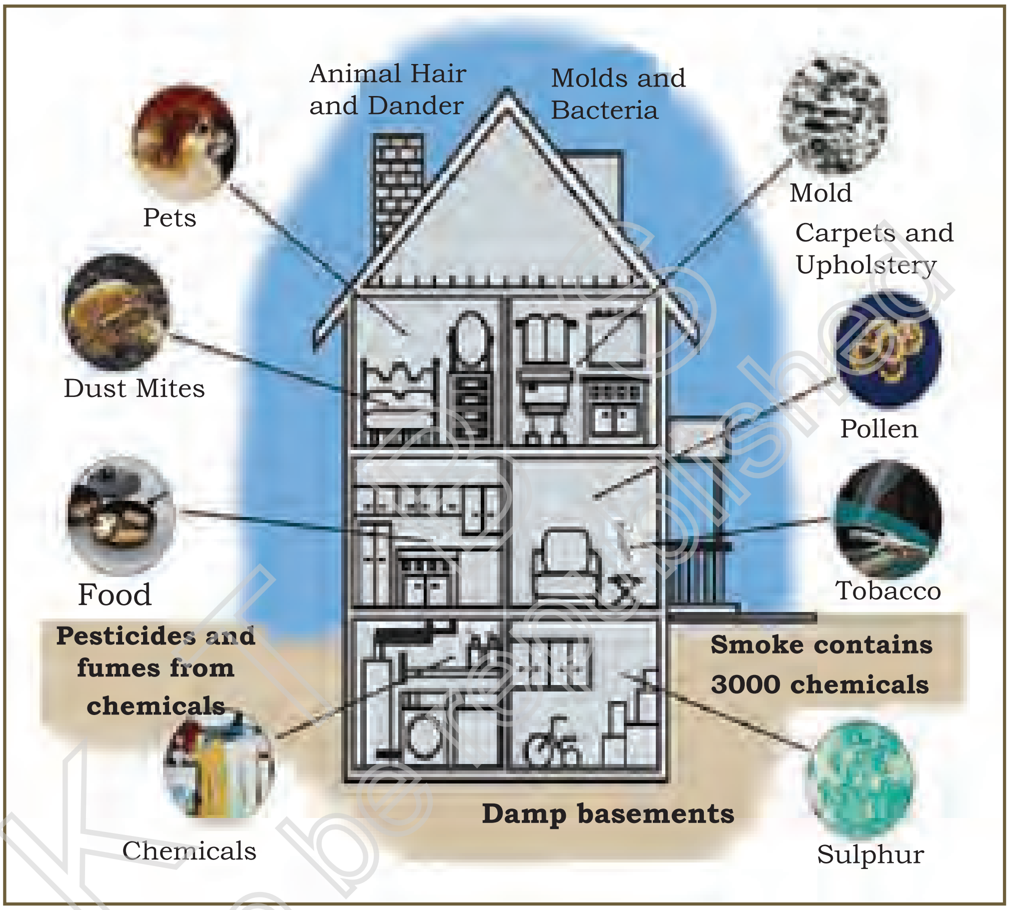

Fig. 2.2 Common sources of indoor air pollution

- Industries to be established away from towns and cities.
- Emissions from industries to be checked and controlled.
- Regulatory rules related to air pollution must be strictly enforced.
- Automobiles to be periodically checked to improve the efficiency of engines to minimise the emissions.
- Use of unleaded fuel and biofuels must be encouraged.
- Educating the public to use public transport.
- Measures of checking air pollution at sources are to be implemented.

Activity 2.1

Find out some measures of controlling air pollution at source.

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Water pollution

Effluents from industries, accumulation of sewage and extensive use of pesticides and fertilizers in agriculture are the major sources of water pollution.

Following are the major water pollutants :

- **Industrial effluents:** Waste materials released from industries are so enormous in quantity that the easiest way of disposal is to release them into the nearby source of water. This is especially true in the case of rivers. Most Indian rivers are polluted this way.
- **Sewage:** The term sewage is used to describe any type of organic waste resulting from human activities. This includes rotten fruits and vegetables, animal and human faeces, and organic effluents from factories.
- **Detergents:** More and more people are now switching over to synthetic detergents in place of traditional soaps and soap powder obtained from vegetable oils. Hence, domestic waste has a high percentage of such detergents. On reaching water bodies, they cause foaming and reduction in the dissolved oxygen content.
- **Agricultural wastes:** Most of the pesticides that we are using today are highly stable and non degradable. Similarly, a variety of fertilizers that are in use today also contain non degradable constituents. These get washed away into water sources.

Know this

The high phosphorous content of detergents and fertilizers allows the rapid growth of organisms which consume the phosphorous compounds. As a result, oxygen content decreases. This change in the ecological character of an aquatic ecosystem is called ***eutrophication****.*

Underground water pollution

Closely associated with water pollution, is another serious problem called underground water pollution. Pollutants like lead, arsenic and fluoride combine with hydrogen, oxygen, iron and chlorine in water and result in poisoning of ground water.

Know this

Arsenic poisoning is a serious problem in our country. 65 million people including six million children in 6000 villages of nine states including Karnataka, are suffering from this problem.

Thermal pollution

Many industries use high temperature furnaces and boilers in their manufacturing processes. The resulting hot effluents are directly released into a nearby water source. This is called **thermal pollution**. It destroys the aquatic life due to the thermal shock.

Marine pollution

You know that seas and oceans occupy about 71% of the earth. Most of the pollutants reaching the atmosphere, condense and fall into these sources, causing marine pollution. Apart from this, agricultural runoff and industrial effluents also enter the sea. Oil seepage from huge tankers is another cause of marine pollution.

Know this

Every year, an estimated 60,000 barrels of oil is entering the sea!

Control of water pollution

- Industrial effluents must be suitably treated to remove the pollutants. Toxic chemical substances must be eliminated. Acids and alkalies must be neutralized. Metallic compounds must be precipitated.
- Effluents coming from furnaces must be cooled to room temperature and treated before being released.
- Sewage water must be treated to remove suspended particles. It must be aerated and then chlorinated to purify water. This water can be reused.

Land pollution

We are now using various kinds of materials in our day to day life. We follow a **use and throw** culture in our society. According to an estimate, every human generates about six kg of trash every day. In recent times, every year billions of tons of cans, bottles and plastic items are being discarded. Only a small fraction of this is reused. The remaining is either burnt or dumped into open lands. Such places are now turning as breeding grounds for insects, rodents and other pests, apart from polluting the land.

In addition to this source, land pollution is also being caused by the agricultural runoff, containing residues of fertilizers and pesticides. Acid rain caused by air pollution, is also contributing to land pollution by altering the acidity and fertility of the soil.

Noise pollution

Sound is an essential part of our life. Any sound which causes unpleasant effects and discomfort to human ears is called **noise.** Today noise has become a source of pollution in the environment, affecting not only human beings, but also animals.

Know this

Noise or sound is measured in units called decibels (db). An increase in noise from 40 db to 80 db means 10,000 times increase in its loudness! Any sound with an intensity of above 100 db is harmful to human ears.

Following are the major sources of noise pollution :

- The gadgets used at home, like mixer and grinder.
- Transport vehicles, especially aircraft.
- Commercial and industrial activities.
- Social and public events.

Activity 2.2

List the sources of noise pollution in the place where you live.

Effects of noise pollution

- Noise pollution directly affects the human nervous system, causing deafness, headache, high blood pressure and heart disorders.
- Noise causes behavioural discomforts. Noise pollution seriously affects animals also.

Let us now look into some of the major global environmental problems, caused by long term air pollution.

Ozone depletion

It is the reduction of the ozone in the stratosphere, about 15 to 60 km. from the surface of Earth.

Depletion of ozone layer is due to the release of substances called **chlorofluorocarbons**(CFCs). They are a product of industrial processes involved in the manufacturing of insulating foams, solvents, cooling equipments like refrigerators and air conditioners. It is also found in various kinds of sprays that we use in our daily life, collectively known as **aerosols**. The ultra-violet rays in stratosphere break the CFCs into chlorine atoms. Chlorine reacts with ozone, breaks it into oxygen.

Know this

One chlorine atom can destroy more than 1,00,000 molecules of ozone!

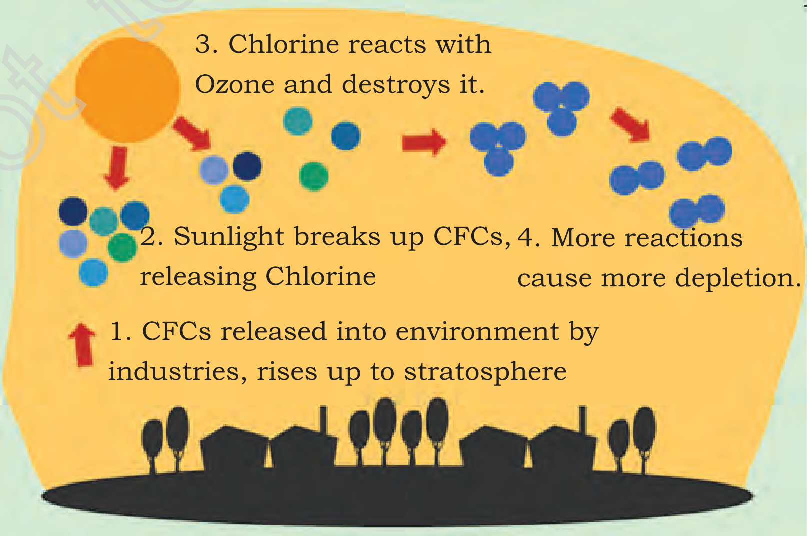
3. Chlorine reacts with Ozone and destroys it.
2. Sunlight breaks up CFCs, releasing Chlorine
4. More reactions cause more depletion.
1. CFCs released into environment by industries, rises up to stratosphere

Fig. 2.3 Action of Chlorine molecules on Ozone

What is the effect of Ozone depletion?

Thinning of the ozone layer allows high levels of UV radiation to reach the Earth. This causes sudden changes called mutations in organisms.

- In human beings, the incidence of skin cancer and cataract increases.
- In plants and animals, it can affect growth and physiological functions.
- It affects the population ratio of phytoplanktons causing serious imbalance in the ecosystem.
- In the atmosphere, it affects the natural balance of gases, particularly affecting the carbon cycle.

Know this

We cannot do much to replenish the depleted ozone. All that we need to do is to phase out the ozone depleting substances from our life. Significant efforts are being made to replenish ozone at the global level in this direction.

Global warming

Global warming refers to the rise in average temperature of the Earth's atmosphere and oceans. Earth's mean temperature is said to have increased by about 0.8^0 C since the beginning of this century. About two thirds of this increase is said to have occurred after 1980s.

Increase in the heat content is much greater in the ocean than in any other source or store of energy. It accounts for more than 90% of the possible increase in the heat content of the Earth system. This warming effect is similar to what is seen in green houses. Hence, it is called green house effect.

The infra red rays released due to the heating of the earth by solar radiation, are trapped by some gases in the atmosphere. This results in increase in the atmospheric temperature. This increase is called **green house effect**. The gases responsible for this effect are called green house gases.

Earth's natural green house effect is responsible for sustaining life on Earth. However, human activities like burning of fuel and clearing of forests have intensified the effect. This has caused what is described as global warming.

Carbon dioxide, oxides of nitrogen, methane and to some extent ozone are the green house gases in the atmosphere.

Know this

A green house is built of any material through which sun light can pass, such as glass or plastic. It gets heated up because the ground inside is heated up, warming the air inside. The air continues to heat up because it gets confined within the green house.

Green houses are used in horticulture to provide warmer temperatures for growing ornamental plants.

Global warming has resulted in melting of the glaciers, causing an increase in the sea level. As a result flooding of sea water is increasing. This results in submerging of lands. Hence, it affects both aquatic and land life.

Acid rain

Do you know that normal rain water is acidic? It has a pH of 5.6. If the precipitation has a pH less than 5.6, it is described as **acid rain**. This situation occurs when oxides of sulphur and nitrogen in the atmosphere combine with water vapour and form sulphuric acid and nitric acid respectively. These precipitate as rain, snow or fog. The main sources of these oxides are combustion of fuels in the industries.

Acid rain affects all forms of life. It affects egg production in aquatic animals and hence, alters the population ratios. It can affect vegetation since the soil becomes acidic. It leaches the nutrients in soil. The leaves of affected plants develop brown spots and cracks. This allows infection of pathogens.

Acid rain is harmful to human health also. It causes skin allergies and respiratory problems.

Acid rain also affects old buildings and monuments. It damages metal and stone structures.

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Know this

Taj mahal in Agra is a mute victim of acid rain, due to gaseous pollutants from a large number of industries in the neighboring areas. The marble lost its glaze. Supreme court ordered shifting of these industries to far off places, to save the Taj.

Radioactive Pollution

We know that radio activity is a phenomenon of emission of Protons (**alpha particles**), Electrons (**beta particles**) and **Gamma** rays due to disassociation of atomic nuclei of some elements. Such emissions also can cause pollution. This is called **radioactive pollution.**

Radiation is of two types : Ionising and non ionising.

Ionising radiations have high penetration power and cause breakage of macro molecules.

Non ionising radiations affect only those compounds which absorb them.

Alpha particles can be blocked even by a piece of paper. Human skin also can block alpha particles. Beta particles can penetrate through skin. They can be blocked by glass and some metals. Gamma rays can easily penetrate skin and damage cells. They cannot be blocked.

Sources of radio active pollution

- Nuclear power plants.
- Nuclear weapons.
- Disposal of nuclear wastes.
- Use of Radio active isotopes.
- Mining and refining of radio active substances like Uranium and Thorium.

Radio active materials react with biological molecules. It can damage DNA, leading to cancer and birth defects.

Know this

The classical example of the effects of radiation is seen in the fall out of atomic bomb dropped at Hiroshima and Nagasaki in Japan in 1945. Long term investigation of survivors have shown abnormalities such as high rate of cancer, leukaemia and other related disorders.

Exercise

I. Choose the correct answer from those given, for the following questions

1. Identify from the following a biodegradable pollutant

a. oxides of sulphur c. lead compounds
b. sewage water d. pesticides

2. Which of the following is the most hazardous air pollutant?

a. Oxides of nitrogen c. Carbon monoxide
b. Carbon dioxide d. Oxides of sulphur

3. Agricultural wastes are causing

a. water pollution c. air pollution
b. both water and land pollution d. land pollution

4. Acid rain refers to precipitation with a pH of

a. less than 5.6 c. above 6.0
b. about 7.0 d. above 7.0

5. Which of the following chemical element is responsible for breaking down ozone in the atmosphere?

a. Mercury b. Lead
b. Carbon d. Chlorine

6. Global warming can be reduced by minimising the release of

a. chloroflurocarbons c. green house gases
b. sewage water d. agricultural wastes

II. Fill in the blanks with suitable words

1. Waste incineration releases mainly ______________.
2. Detergents cause a decrease in the __________ content of water.
3. Ozone in the atmosphere protects us from harmful ________ radiation.
4. Oxides of nitrogen and sulphur are mainly responsible for causing ____________.
5. Noise beyond __________ is dangerous to human ear.

III. Answer the following questions

1. Distinguish between biodegradable and non biodegradable pollutants. Give examples.
2. Make a list of the main sources of air pollution.
3. Define marine pollution. List two main causes.
4. Explain the need for treating sewage water.
5. Make a list of the effects of noise pollution.
6. Write a brief note on radio active pollution.
7. Suggest measures to control acid rain.

* * *

CHAPTER 3

PERIODIC CLASSIFICATION OF ELEMENTS

After studying this chapter you

- state Dobereiner's law of triads.
- state Newland's law of octaves.
- state Mendeleev's periodic law.
- give reason to state that Mendeleev's periodic law is an improvement over Newland's law.
- state Moseley's modern periodic law.
- state the advantage of using atomic number instead of atomic mass in the statement of periodic law.
- explain the main features of modern periodic table.
  a) groups
  b) periods
  c) 's' 'p' 'd' 'f' blocks
  d) transistional elements
  e) periodic trends in atomic radius, ionisation energy, electrochemical nature, metallic nature.
- predict valency and valence electrons when group number is given.
- predict period number and the block when atomic number of an element is given.
- identify the relationship between electronic configuration and formation of groups and periods in the periodic table.
- state the reasons for giving a separate place for 'f' block elements.
- state the advantages of periodic table.
- appreciate the gradual improvement in the development of periodic table and discuss the possibilities of further improvement.

Know these terms

K,L,M -1,2,3,→Shells

s,p,d,f → sub shells or orbitals. The term orbit is used in the case of subdivisions of orbitals. 'p' orbitals or sub shell has three orbits.

Periodic Classification of Elements:

In our daily life, we come across a variety of elements and compounds. Gradually, chemical vocabulary is enhanced by the discovery of new elements and their compounds. Comprehensive study was compelling and this lead to the classification of elements. Classification makes the activities and studies systematic. In a vegetable shop, in a medical shop, in the library-we find classification to be helpful.

Activity 3.1

How does the classification and arrangements of containers of food ingredients in the kitchen help us?

How does the classification of living organisms or plants make the study of biology systematic? Make a list of the advantages.

There were several attempts to classify the elements known at that time. Classification on the basis of states of matter cannot be justified because, bromine and mercury which are liquids at room temperature cannot be placed in the same group.

It is possible to classify elements into metals and nonmetals. This method can be justified as there are more common characteristics in both the groups. But it is not satisfactory. Imagine sodium, iron and gold which are different in properties metals in the same group ! Any type of classification of elements should be useful. **William Prout** in the year 1815 suggested that atomic mass can be used as the basis for classification of elements. First attempt of classification was made by Dobereiner.

***Johan Wolfgang Dobereiner** [1780 to 1849]*
Dobereiner was a German scientist. He was largely self taught. He developed extra ordinary skills in chemical research. As a professor at the university of Jena in Germany , he conducted research on the manufacture of Vinegar, abundance of elements in the earth crust, use of mineral water for medical purposes, and use of plantinum as catalyst. He invented hydrogen igniter with platinum as catalyst. After studying the work of John Jacob Berzelius on the atomic masses, he presented the historical law of triads which is a milestone in the classification of elements.

Fig. 3.1
Johan Wolfgang Dobereiner

Dobereiner formed a group of three elements called triads having similar properties and arranged them in the increasing order of their atomic masses.

	Element	**Atomic Mass**
Example 1.	Chlorine	35.5
	Bromine	80
	Iodine	127
Example 2.	Calcium	40
	Strontium	88
	Barium	137

Activity 3.2

Find the average of atomic masses of the first and third elements in the above triads. Compare the average with the atomic mass of middle element. What is your conclusion?

Activity 3.3

*In a triad of three elements **A B** and **C** the atomic masses of **A** and **B** are 80 and 120 respectively. What is the atomic mass of the element **C**?*
Answer 160.

The law of triads does not help in classifying all the known elements. However the law of triads gave a clue that atomic mass can be used as the means to find suitable laws for the classification of elements. Persuing the clue given by Dobereiner, Newlands formed law of octaves.

John Alexander Reina Newlands [26-11-1837 to 29-7-1898]. Newlands was born in London, and studied in Royal college of London. He was a chemist in a sugar refinery. He was interested in social reforms also. He served as a volunteer to unify Italy. His famous contribution is 'law of octaves', which was ridiculed earlier only to be recognised after the work of Mendeleev.

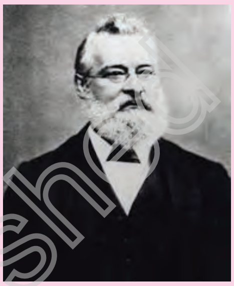


Fig 3.2
John Alexander Reina Newlands

Newlands arranged the elements known at that time, in the increasing order of their atomic masses. He placed eighth element below the first. He found that when elements are arranged in the ascending order of their atomic masses, starting from any one, every eighth element is similar to the first in chemical properties. That means starting from any one, the properties of every eighth element are repetitions of the first element. It is like the musical notes. The word 'Octaves' is used in music. This is the reason for calling it the law of octaves.

Table 3.1 The table prepared by Newlands

Western music	Do	Re	Me	Fa	So	La	Ti
Indian music	Sa	Re	Ga	Ma	Pa	Da	Ni
	I	2	3	4	5	6	7
	H	Li	Be	B	C	N	O
	F	Na	Mg	Al	Si	P	S
	Cl	K	Ca				

Though Newlands prepared a table keeping every eighth element below the first in an attempt to classify the elements, it was not possible to extend the law after seventeen elements. Newlands was ridiculed for comparing chemistry with music. However Newlands contributed the word 'periodic' in the classification of elements. The length of the repetition of properties is eight places according to Newlands. That means periodicity of repetition of properties is eight.

Recall

What are the other areas in which we use the word periodic? In a wave motion crests and troughs repeat periodically. The motion of a pendulum is periodic. New moon days and Full moon days have a periodicity of approximately one month. News papers have periodicity of one day. Magazines are called weekly, monthly, depending upon their periodicity. The heart beats of a heart are periodic. Festivals like Ramzan, Christmas, Ugadi are periodic. Recall the famous Kannada poem of Dr. D. R. Bendre "uga ugadi kaledaru ugadi marali baruthide..." Ugadi repeats every year. Can you imagine the properties of the element sodium being repeated in the element potassium?

The law of octaves was studied deeply and extended by Russian chemist Dmitri Mendeleev. According to him "The properties of elements repeat at regular intervals when arranged in the increasing order of their atomic mass. The periodicity is not regular at eight. It may be 8th, 18th or 32nd. Mendeleev altered Newlands law of octaves by replacing the word 'Octaves' by 'regular intervals'. Mendeleev's periodic law is stated as "**The properties of elements are periodic functions of their atomic mass"**. The meaning is that the properties of elements repeat periodically at regular intervals when arranged in the increasing order of their atomic mass.

Dmitri Mendeleev [1834-1907] Dmitri Invonovich Mendeleev was a Russian Chemist and inventor. He studied in Moscow, France and Germany. He worked as a science teacher. His famous research papers were **Carbonic Chemical Studies** and **Water and Alcohol Mixture**. He inspired many students. When he published his periodic table there were only 63 known elements. Periodic table of Mendellev helped in the discovery of many new elements whose properties were predicted by Mendeleev. He was able to live upto 73 years, despite his poor health.

Fig 3.3
Dmitri Mendeleev

Mendeleev constructed a table of elements keeping them in groups and columns. The table attracted the attention of many chemists. Elements having similar properties were kept in the same group. He left some vacant places in the table citing the reason that the elements in that place are not yet discovered. Mendeleev was able to predict the atomic mass and properties of the elements of those vacant places even before their discovery. Periodic table of Mendeleev helped in the discovery of new elements like germanium. Mendeleev's work can be regarded as an insightful work in the abscence of the knowledge of electronic configuration. It is not much different from modern periodic table. The limitations of the Mendeleev's periodic table are taken care of in the construction of modern periodic table in the light of new findings and with the help of knowledge of electronic configuration.

Modern periodic law is based on atomic number and not on atomic mass, to solve the problem of position of isotopes. The modern periodic law as stated by Moseley is "The properties of elements are periodic functions of their atomic number".

Think

Carbon has four isotopes namely ${}_{6}C^{11}$, ${}_{6}C^{12}$, ${}_{6}C^{13}$, ${}_{6}C^{14}$, If atomic mass is used to classify the elements, carbon has to be placed in four places. Can you reason out why atomic number is more useful than atomic mass to classify the elements?

Recall

The meaning of isotope is iso- 'same' tope- 'place' Atoms having different atomic masses with the same atomic number are given the same place in the periodic table.

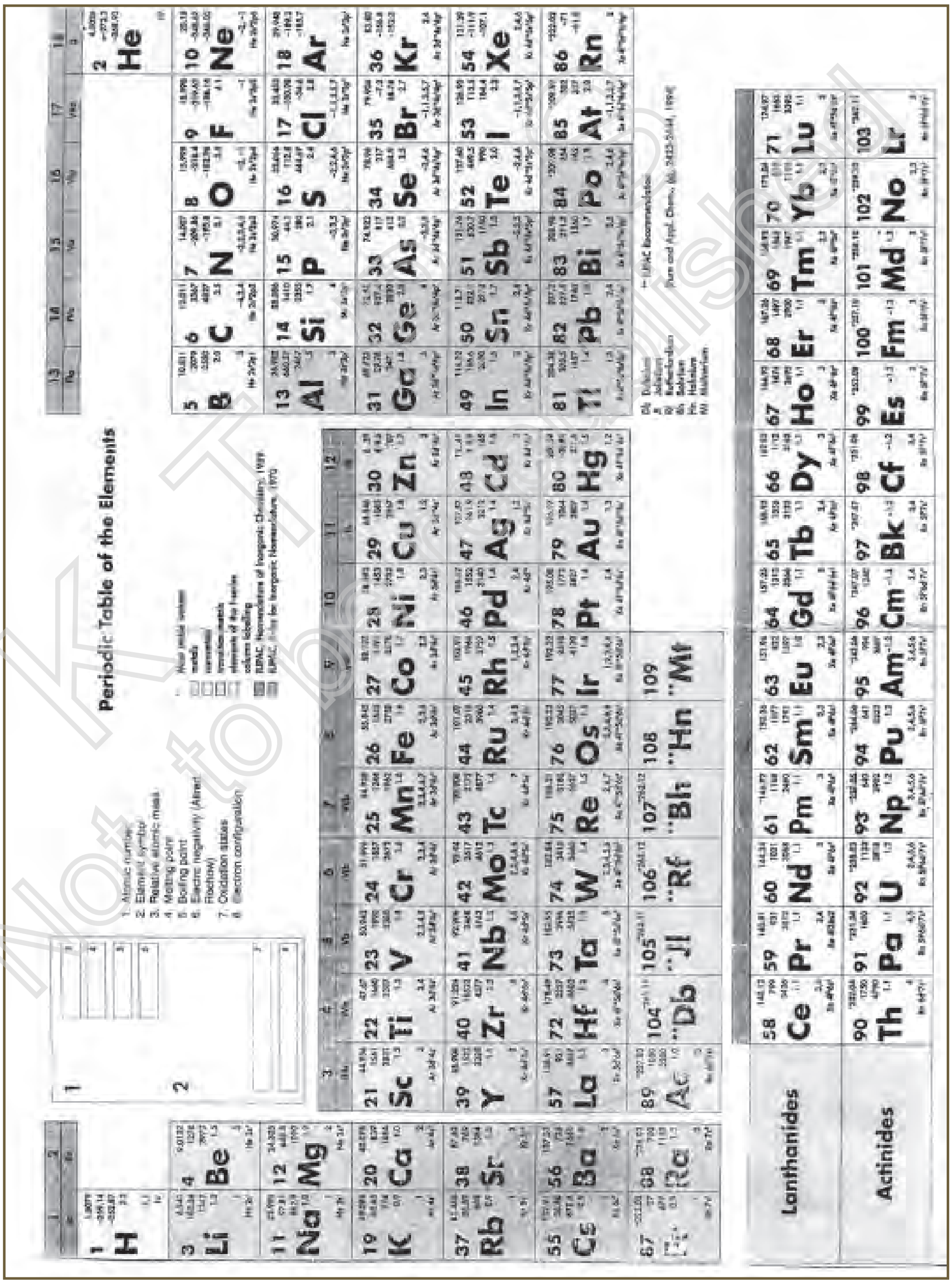
Henry Gwyn Jeffreys Moseley : [23 - 11 - 1887 to 10 - 8 - 1915] Moseley was an English physicist. He was a research scholar at the University of Oxford. The main field of his research was X-ray spectroscopy. Combining physics and mathematics he was able to provide a solid experimental evidence for Rutherford's and Neils Bohr's atomic model. He was killed in action during the first world war. But his contribution to science during his life span of 27 years is highly considerable.

Fig 3.4

Henry Gwyn Jeffreys Moseley

Modern Periodic table

The modern Periodic table was adopted by IUPAC in 1984. IUPAC is short form of International Union of Pure and Applied Chemistry Geneva.



Periodic Table of the Elements

1. Atomic number
2. Element symbol
3. Relative atomic mass
4. Melting point
5. Boiling point
6. Electric negativity (Allred Rochow)
7. Oxidation states
8. Electron configuration

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Db	105 Jl	106 Rf	107 Bh	108 Hn	109 Mt									

Lanthanides	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Db Dubnium
Jl Joliotium
Rf Rutherfordium
Bh Bohrium
Hn Hahnium
Mt Meitnerium

IUPAC Recommendation, Pure and Appl. Chem., 66, 2423-2444, 1994

Table 3.2 Modern periodic table

Activity 3.4

Look at the modern periodic table given. Can you see the vertical columns? They are called 'groups' How many groups or vertical columns are there in the table? What is so special about the groups?

Elements having similar properties are kept in the same group. For example observe group number 17. Fluorine, Chlorine, Bromine and others are the members of this group. Elements of this group resemble one another in many chemical properties. You may not find complete similarity in some of the groups.

Activity 3.5

Observe the 18th group of the periodic table. Make a List of the members of this group. Using your knowledge of chemical bonding studied earlier, can you give reasons for the inert nature of the elements of this group? What is the valency of the elements of this group?

Group number 18 is also called zero group, because the valency of these elements is usually zero. They do not form chemical bond on their own with other elements. They are called **Noble gases** instead of inert gases. Elements of this group have completed shells of electrons. That means the atoms of the elements of 18th group have shells which are filled with electrons to the maximum capacity. Elements like Argon, Xenon have eight electrons in the outermost shell. This type of electronic structure is called **octet structure**. If an atom has octet structure then also it will show a tendency of inert nature. Stable gases or Noble gases or inert gases of 18th group have either completed shell or outer octet structure.

Know this

*The element fluorine is the most reactive of all the elements in the periodic table. It reacts even with glass. It is called 'The element that consumes everything' It reacts with xenon, an inert gas also, to form xenon hexa fluoride. When **Henry Moissan** isolated fluorine gas from its compound it affected his eyes and he received science academy award with his eyes covered with black bandage.*

Activity 3.6

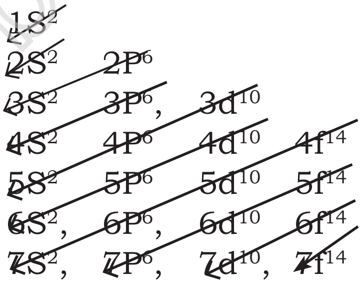
Look at the periodic table. You can see the horizontal rows. How many horizontal rows are there in the periodic table? Your answer may be 7 or 9. In reality there are 7 rows. How? Let us study. The horizontal rows are called 'periods'.

In each period of the periodic table the elements are arranged in the ascending order of their atomic number. Remember atomic number of an element is an integer and not a fraction. There are short periods, long periods and incomplete periods in the table. Can you identify them? There are totally seven periods in the periodic table.

A part of 6th and 7th period from atomic numbers 58 to 71 and 90 to 103 respectively, are kept separately at the bottom of the periodic table. Elements of separated periods are called lanthanides and actinides. Why are lanthanides and actinides kept separately? Are we not breaking the periodic law? Yes But we must remember that periodic table is constructed for our convenience. Lanthanides and actinides do not fit into the elements of the main table as there is more horizontal similarity rather than vertical similarity in the case of these elements. For practical purposes the separation can not be avoided.

Let us study the relationship between electronic configuration of an element and the formation of periods in the periodic table. The knowledge of electronic configuration that you have studied earlier is helpful to understand this. It is appropriate to recall about the distribution of electrons in different shells and subshells.

Table 3.3 Recall Distribution of electrons in shells and Orbitals



Periods are formed according to the way in which electrons get filled up in different shells and orbitals. For example first period of the table is completed when the first shell of the atom is completely filled up. First period has two elements namely hydrogen and helium with electronic configuration $1s^1$ and $1s^2$ respectively.

Second period of the table is completed when the second shell of the atom is completely filled up with electrons. The argument cannot be extended further. Third shell of an atom has the maximum capacity of 18 electrons. But the third period has only 8 elements but not 18 elements. Electrons follow the normal order upto 1s, 2s, 2p, 3s and 3p. After ‘3p’, electrons occupy ‘4s’ leaving ‘3d’ Orbitals/subshell, vacant. Refer to the pattern of filling up of electrons in shells and orbitals. Elements where electrons of their atoms occupy ultimate shells leaving penultimate shells partially vacant are called **transistional elements**. In other words electrons are added to the vacant inner subshells. This is applicable to 'd' block elements. 'd' block elements are called **outer transitional elements**, Similarly the same thing happens in the case of 'f' orbitals of pre penultimate shell. Elements applicable to 'f' block are called inner transitional elements. A new group commences when the electron enters a new shell while filling up shells and subshells.

Based on electronic configuration all the elements in the periodic table can be grouped into four general categories. They are ‘s’ block, ‘p’ block, ‘d’ block and ‘f’ block elements.

How to find the block to which an element belongs? For example.

Atomic number of sodium is 11. To which block does it belong? To find this we have to write the electronic configuration of sodium atom. $1s^2$, $2s^2$, $2p^6$, $3s^1$. The Orbital occupied by the ultimate electron is ‘s’. Hence sodium belongs to ‘s’ block.

Activity 3.7

Find the block to which the following elements belong.

Aluminium Atomic number	*13*
Iron Atomic number	*26*
Cerium Atomic number	*58*

How to find period number of an element when its atomic number is given? It is simple. Write the electronic configuration and find out the number of shells. Total number of shells indicates period number. For example calcium with atomic number 20, belongs to the 4th period because its atom has four shells.[Highest shell number also indicates the period]

Activity 3.8

To which period number of the table, do the following elements belong?

1) Manganese Atomic number 25 2) Zinc Atomic number 30

To find the group number of an element the electron capacity of 's', 'p', 'd' and 'f' orbitals have to be considered, you will study about them in higher classes. It should be remembered that the cause of periodicity of properties is the recurrence of similar electronic configuration. The periodic trends in the properties of elements and the electronic configuration of their atoms are related to each other. We can write a generalised eletronic configuration with respect to the elements of a given group.

Let us study about the periodic trends in the properties of elements in the periodic table.

Periodic table does not identify periodicity in chemical properties only. It also deals with some quantitative parameters and the gradation in the properties of elements. Surprisingly these parameters are interrelated and deciding factors of the chemical behaviour. There are regular gradations in these properties with unusual exceptions also. Let us consider some of these properties and identify the general trend.

1. Atomic Size : Size of an atom is difficult to define, since the position of moving electron in the outermost orbit is not clearly defined. But still the approximation is possible and significant. Size of the atom decides ionisation energy and electron affinity. Electron affinity decides electronegativity and electropositivity. The distance between the centre of an atom and its outermost orbital is taken as atomic size.

The size of the atom as a general trend increases as we go down a group and decreases as we move from left to right along a period. How? Down the group new shell the atom. Along a period, there will not be any change in the number of shells but more electrons are added to the same shell and the nucleus exerts greater inward pull on the electrons. Example: atomic size Li> Be> B> C> N> O> F

2. Ionisation Energy : Ionisation energy is the energy required to remove the outermost electron from the free and isolated atom of an element. Ionisation energy increases along a period and decreases down a group. There is inverse relationship between atomic size and ionisation energy.

Activity 3.9

Observing the periodic table give reasons for the following

1) Sodium atom has lower ionisation energy than chlorine atom.

2) Sodium atom has lower electron affinity than chlorine atom.

3) Atomic size of sodium atom is greater than that of chlorine atom.

3. Electro Chemical Nature : Atoms which give up electrons easily are called electropositive. For example sodium atom. Atoms which receive electrons easily are called electro negative. For example : Chlorine.

Recall

Why should the atoms give up or receive electrons? It is to form chemical bond. In which case atoms do not receive or give up electrons but share electrons?

Electro positivity decreases along a period and increases down the group. Similarly Electronegativity increases along a period and decreases down the group.

4. Metallic Nature : Metallic nature decreases along a period and increases down the group.

For example in 14th group there are elements namely carbon, silicon, germanium, tin and lead. Carbon and Silicon are non metals, (Note : graphene is considered metallo carbon) tin and lead are metals. Germanium has characteristics of non metal and metal. Elements which are not distinctively metals and possess some physical properties of non metals are called metalloids.

Activity 3.10

Make a list of the members of 15th group of the periodic table. Name the distinct non metals of the group. Name the distinct metal of the group. You note that Antimony though has metallic properties possesses brittle nature of non metal. It is not malleable and ductile.

It can be concluded that variation in the pattern of gradation is very interesting but you study this in higher classes.

Activity 3.11

Observe the periodic table.

Taking first period and 17th group of the periodic table write gradation of properties with respect to the following,

1) Atomic size

2) Ionisation energy.

3) Electropositivity and electronegativity.

Advantages of the Periodic table

1. Study of chemistry is simplified and organised leading to easy access of data of the elements.
2. It was possible to predict the atomic mass, some of the properties and other details of elements which are yet to be discovered. Many elements were discovered during the life time of Mendeleev.

Note : There is striking similarity between the periodic table constructed emperically by Mendeleev and the modern periodic table based on the electronic configuration and nature of chemical bond. Commonsense plays an important role in scientific research.

3. Interpretation of trends and periodicities of properties of elements provided a clear understanding and proof for the atomic behaviour.
4. It is possible to predict the properties of elements by considering the position of elements in the periodic table. On the other hand, properties of an element help us to predict the position of an element in the periodic table.

Think it over

Periodic table was improved over a period of time. After a lot of discussion and thinking, the long form of periodic table is accepted in the year 1984. Can you try to improve it further if you become a chemist? How?

Exercise

I. Four alternatives are given to each of the following incomplete statement / question. Select the most appropriate alternative :

1. In a triad of 'A', 'B', 'C' elements, if the atomic mass of 'B' and 'C' are 150 and 200 respectively, the atomic mass of 'A' is,

   a. 100. b. 125.

   c. 250. d. 350.

2. In the periodic table, the following repeats at regular intervals

   a. Atomic number. b. General properties.

   c. Atomic mass. d. Isotopes.

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3. In the periodic table the elements of 18th group in general,
   a. form ionic bond. b. form covalent bond.
   c. form hydrogen bend. d. do not form bond.
4. The following is an example for inner transitional element
   a. sodium. b. chlorine.
   c. argon. d. uranium.

II. Fill in the blanks

1. The group number of the element neon is __________ .
2. The period number of the element aluminium is __________.
3. Horizontal similarity can be observed in the period number __________ .
4. The first element of 14th group is carbon which is a non-metal. The metallic members of this group are ________ .

III. Give reasons for the following

1. 'f' block elements are kept separately in the periodic table.
2. Atomic size decreases across the period.
3. In the first period, hydrogen and helium are not placed adjacent to each other.
4. In the construction of periodic table the periodic law is broken, in some places.

IV. Answer the following

1. What are periods and groups in the periodic table?
2. State the modern periodic law.
3. Atomic mass is not useful to construct the periodic table. Give reasons with an example.
4. In which part of the periodic table do we find mostly non metals?
5. What are transitional elements?
6. What are metalloids? Give an example.

CHAPTER 4

SILICON

After studying this chapter you

- realise the presence of compounds of silicon in building materials, ornamental stones.
- explain the chemical properties of silicon.
- describe the extraction of amorphous and crystalline silicon.
- differentiate between amorphous and crystalline silicon.
- list of the uses of silicon and silicon compounds.

Introduction

Even though man was homely with the sand, an important ingredient of the solid crust of this planet, it is surprising that he realised its chemical composition very late. This was because of the reluctance of soil/mud to undergo chemical reaction on heating. Sand and quartz, compounds of silicon exist in various forms and this was considered an element for a very long time. Berzelius produced crude silicon from silicon dioxide (sand was identified as silica) and proved that sand is a compound and not an element. May be the ignorance of properties, difficulty of isolation, lack of equipment and technique-the silicon was not studied or used for many years even after isolation.

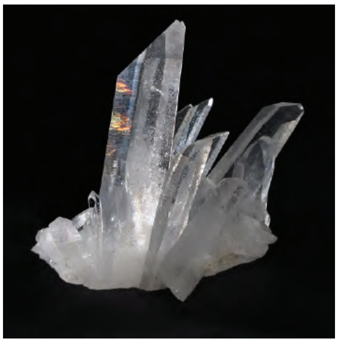


Fig 4.1 Quartz

Know this

Silicon is derived from the Latin word Silicium which means stone or flint.

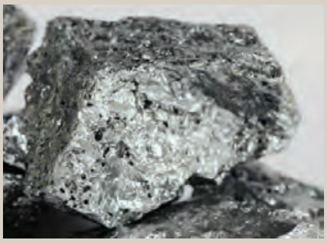


Fig 4.2
Crystalline Silicon

John Berzelius

- *Earlier, pictures were used as symbols of elements. Berzelius was first chemist, who introduced the representation of elements or their atoms in terms of letters. This notation of Berzelius helped us to write the structural and molecular formulae of complex molecules. Berzelius in a mood of frustration is reported to have said, "Only devil can write chemistry because it grows at a very fast pace" !*
- *In 1824, John Berzelius first isolated silicon and found it to be an element.*

Fig. 4.3 John Berzelius

General Properties of Silicon

Symbol : Si

Atomic Number : 14

Mass Number : 28

Electronic Configuration : $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^2$ or $[Ne]\ 3s^2\ 3p^2$

Allotropes : Amorphous silicon, Crystalline silicon

Occurrence

In Earth's crust, silicon is the second most abundant element next to oxygen. It is more widely distributed in dust, sand and planets as various forms of silicon dioxide (silica) or silicates. Silicon compound is the chief constituent of semi precious stones like garnet, zircon, topaz and opal.

Silicon exists in two allotropic forms - amorphous and crystalline.

Extraction

Finely powdered silica (sand or quartz) is mixed with magnesium powder and heated in a fire - clay crucible. Magnesium oxide and silicon are formed. The product is washed with dilute hydrochloric acid to dissolve magnesium oxide, a basic impurity. Then it is washed with hydrofluoric acid to remove unreacted silica. The powder left behind is silicon in its amorphous form.

$$SiO_2 + 2Mg \xrightarrow{\text{Heat}} Si + 2MgO$$

Extraction of Crystalline Silicon

Crystalline silicon is obtained by reducing silica with coke. When excess of silica is heated with coke in the electric furnace in the absence of air, dark grey coloured silicon is obtained in its crystalline form. (Excess of Silica must be used; otherwise carborundum (SiC)is formed).

$$SiO_2 + 2C \xrightarrow{\text{Heat}} Si + 2CO\uparrow$$

Comparison of Properties of Amorphous Silicon and Crystalline Silicon

Amorphous silicon	**Crystalline silicon**
1. It is a brown powder.	1. It is a dark grey, crystalline solid. It roughly resembles the structure of diamond.
2. It does not conduct electricity at low temperature.	2. Slightly conducts electricity.
3. More reactive.	3. Less reactive.
4. When heated in the air, it oxidizes at the surface level and it catches fire.	4. It does not burn in the air even when heated.

Though silicon is a non - metal, it is a semi conductor at room temperature.

Find out

Find the group number period number of silicon in periodic table. Make a list of the other members of that group.

Chemical Properties

It burns brilliantly in the air and vigorously in oxygen to form silicon dioxide.

$Si + O_2 \rightarrow SiO_2$

In this reaction there is liberation of heat energy. Chemical reactions which liberate heat energy are called **exothermic reactions**.

Silicon is insoluble in water, but slowly decomposes with steam. When silicon is in red hot state, liberating hydrogen.

$$\underset{\text{Steam}}{Si + 2H_2O} \rightarrow SiO_2 + 2H_2\uparrow$$

Recall

When Steam is passed over hot Iron, Zinc or Magnesium, Hydrogen is liberated along with the formation of their respective oxides. Silicon has resemblance with metals, in this property even though it is a nonmetal.

When a mixture of silicon and coke is heated in an electric furnace, silicon carbide (carborundum) is formed.

$Si + C \rightarrow SiC$

This is an **endothermic reaction** since heat from the furnace is used for chemical reaction.

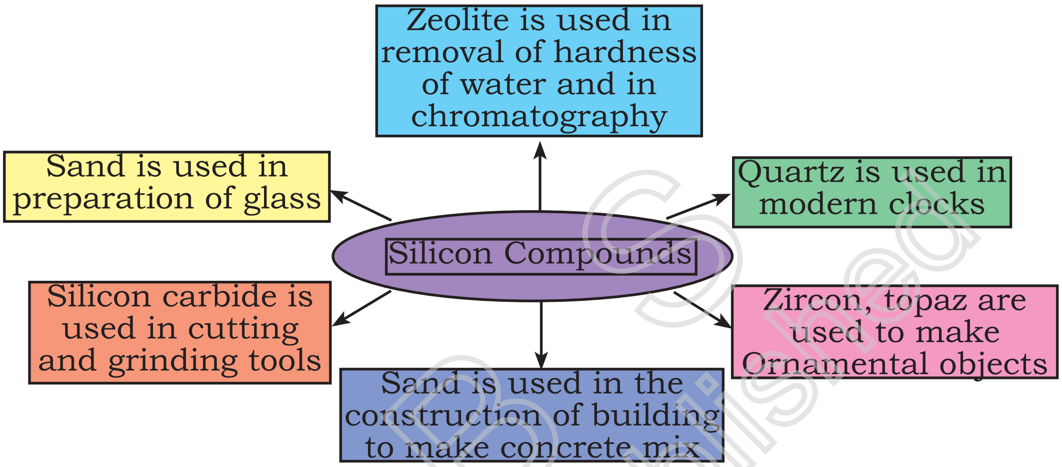
Activity 4.1

Put half a Spoonful of glucose powder into your mouth. There will be a cooling effect in the mouth. Take a small quantity of detergent powder or washing soda in your hand and wet it with water. You feel heat. Like exothermic and endothermic reactions, there are exothermic and endothermic dissolutions also.

Note

Dissolution of ammonium chloride, common salt and sugar in water are endothermic. Where as the dissolution of sodium hydroxide, calcium oxide and sulphuric acid is exothermic. Combustion of fuel is exothermic reaction, but cooking of rice is endothermic reaction.

Uses of silicon and its compounds


Zeolite is used in removal of hardness of water and in chromatography
Sand is used in preparation of glass
Quartz is used in modern clocks
Silicon Compounds
Silicon carbide is used in cutting and grinding tools
Zircon, topaz are used to make Ornamental objects
Sand is used in the construction of building to make concrete mix

- The largest application of silicon, as a raw material is in the production of silicones (in organic polymers). Silicones are used in water proofing treatments, moulding compounds, insulating material for electric motors and other electrical appliances.

Many of the plug points of heating circuits are made from silicones.

Silicones are rubbery compounds of Silicon, Oxygen and Hydrocarbons. Unlike common Organic Polymers, they do not catch fire and hence they find application in fireproof suits and insulating materials

- Silica gel is used in chromatography.
- The element silicon is an intrinsic semiconductor. This can also be converted in to more efficient extrinsic semiconductor through doping. These semiconductors find applications in transistor, diodes, etc and also in I.C. [Integrated circuits]

Activity 4.2

Collect microchips, diodes, transistor from your nearest electronics shop and get information about their functioning.

Think

Silicon is used widely even though Germanium is a better semiconductor material, Why?

Find Reason

Carbon is not a semiconductor inspite of it's group being 14th group. Why?

- You might have observed the person sharpening knives, and a pair of scissors on a rotating wheel. The wheel is made up of silicon carbide. Granite is polished by silicon carbide. If possible collect a piece of broken silicon carbide and use it as pencil sharpener.
- Silica crystals of different size embedded on paper is called emery paper or sand paper.

Activity 4.3

Collect emery paper of different crystal size and interact with a carpenter to realise the use of such paper.

- Due to the high thermal capacity and non combustible property of sand, it is used as sand bath during roasting, sand bath is also used in laboratory to carry out chemical reaction.

Activity 4.4

Dip emery paper or Sand paper in water, take out and shake it well. There will be no traces of water on the paper.

Generally compounds containing oxygen are water attracting. Though silica contains more oxygen, it is not water attracting. It is really wonderful.

Though the reason is not confirmed, it may be due to the absence of porosity in the polymer of silicon. The structure is so compact that water cannot enter. You learn more about it in higher classes.

Biological significance and hazards

Diatoms, radiolaria and siliceous sponges use biogenic silica as a structural material to construct their shells. Some plants, for example paddy, need silicon for their growth.

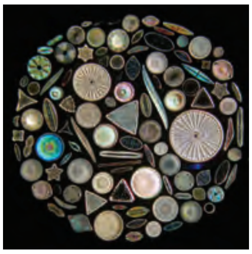


Fig. 4.4 Diatoms

Miners and stone breakers, in asbestos factory, glass factory cement factory sometimes suffer from a professional hazard - **silicosis.** This is because of the entry of silica into lungs. Silica particles are suspended in the air in the mining area, hence they enter lungs because of long exposure to pollution. The workers must be provided with a gas mask to protect their health.

Exercise

I. Four altertnatives are given to each of the following incomplete statement / question. Choose the right answer

1. The acid used to remove unreacted silica in extraction of silicon is

   a. hydrochloric acid
   b. hydrofloric acid
   c. nitric acid
   d. sulphuric acid

2. The other product in the following chemical equation is, $Si + 2H_2O \xrightarrow{\Delta} SiO_2 +$ __________

   a. H_2
   b. O_2
   c. Si
   d. O_3

3. Which silicon compound among these is used as insulating material?

   a. silicon dioxide
   b. silicon carbide
   c. silicones
   d. zeolite

II. Fill in the blanks with suitable words

1. Two allotropic forms of silicon are, amorphous silicon and __________ .

2. Crystalline silicon is obtained by reducing silica with ______________.

3. When a mixture of silicon and coke is heated in an electric furnace, the product obtained is _________ .

III. Match the following

	A	B
1.	Water softner	a) calcium silicate
2.	Abrasive material	b) permutit
3.	Constituent of concrete mixture	c) silicone
		d) silica
		e) carborundum

IV. Answer the following

1. What is the role of hydrochloric acid and hydrofluoric acid in the extraction of silicon?
2. Name the element which is most abundant in earth's crust
3. Write the chemical equations of the reaction taking place when silicon reacts with

   a. oxygen   b. steam
4. How is silicon carbide obtained?
5. Describe the methods of extraction of amorphous silicon and crystalline silicon.

CHAPTER 5

GREEN PLANTS AND CHORDATES

After studying this chapter you

- understand the differences between nonvascular and vascular plants.
- learn the characteristics of red algae, brown algae and green algae.
- recognise the characteristics of bryophytes and pteridophytes.
- differentiate between gymnosperms and angiosperms.
- understand the diversity among vertebrates.

You are familiar with the **five kingdom** classification of living organisms. You are aware that higher plants are placed in the **Kingdom Metaphyta (Plantae)** and higher animals are placed in the **Kingdom Metazoa (Animalia)**. In this chapter, you will become familiar with the classification and examples of higher plants and also vertebrates.

Let us recall Kingdom Metaphyta. It includes the following groups

A. NONVASCULAR PLANTS (xylem and phloem absent)

1. Multicellular Algae

- Red algae
- Brown algae
- Green algae

2. Bryophytes

B. VASCULAR PLANTS (xylem and phloem present)

3. Pteridophytes

4. Gymnosperms

5. Angiosperms

Multicellular Algae

Algae are a diverse group of autotrophic organisms ranging from the simplest unicellular forms to the most complex multi cellular forms. You have studied about two groups of algae in your previous classes, the **blue green algae** placed in **Kingdom Monera** and **golden brown algae** placed in **Kingdom Protista**. Let us now study about three more groups, namely, the red algae, the brown algae and the green algae.

Most of the examples of algae are multicellular. (Exceptions are green algae like *Chlorella* and *Chlamydomonas*.) These algae are relatively simple in organization compared to true plants. Their tissues are not organized into distinct structures as found in land plants. The largest and most complex forms are marine and are commonly called **sea weeds.** (Eg. *Sargassum*) Among the largest algae are the giant **kelps** which grow to about 60 m in length and Eg. *Macrocystus.*

The plant body is called **thallus.** The cells are typically eukaryotic, with a prominent nucleus and many plastids. The cellwall is composed of cellulose and pectin.

In green algae, green pigment **chlorophyll** is maximum. Eg. *Spirogyra* and *Ulothrix*. In red algae,in addition to chlorophyll, a red pigment called **phycoerythrin** is present. Eg. *Batrachospermum* and *Polysiphonia.*

In brown algae, in addition to chlorophyll, **xanthophyll** is present which gives brown colour to thallus. Eg. *Sargassum* and *Ectocarpus.*

Know this

We have fossil record of algae dating back to nearly three billion years. Such algal generations are surviving even now!

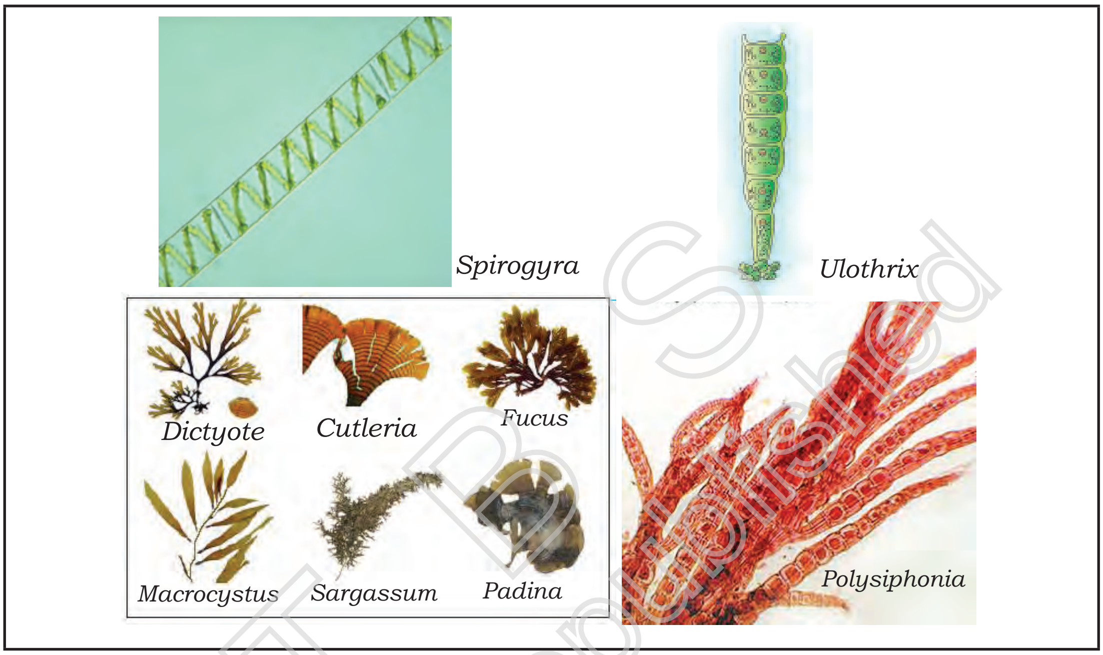


Fig. 5.1 Examples of higher algae

Algae reproduce by vegetative, asexual and sexual means. Vegetative reproduction occurs by fragmentation in which the thallus breaks into small fragments which grow into a new plant. Asexual reproduction generally takes place by the formation of spores. Sexual reproduction involves fusion of male and female gametes.

Know this

- Algae are among the major producer community in the marine ecosystems.
- Some species of algae are used in the manufacture of cattle feed.
- **Algin**, a substance obtained from some brown algae, is used in the preparation of ice creams and chocolates.
- **Agar,** a substance obtained from, *Gelidium* a (red alga) is extensively used as a medium for culturing bacteria in the laboratory.
- A red alga called *Porphyra* is used as a condiment.

- Algae growing in decaying water liberate oxygen and help in purification of water.
- *Laminaria*, a brown alga, is used in the production of potassium and iodine.

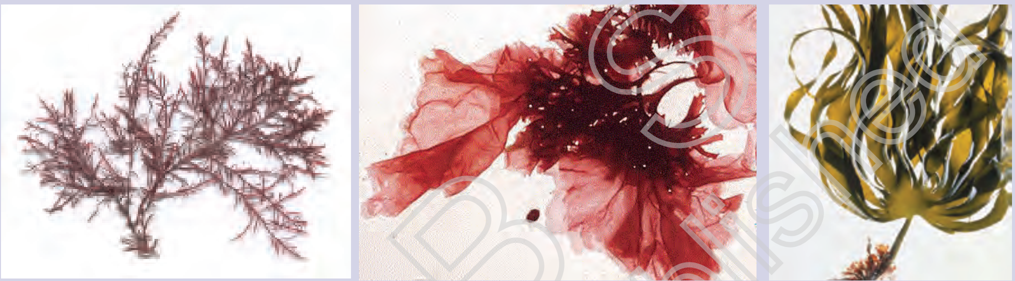

Gelidium *Porphyra* *Laminaria*

Fig. 5.2 Economically important Algae

Bryophyta

During rainy season you might have observed a mat like growth of green colour patches on some tree trunks, damp walls and rocks. They appear to be tiny plants. The common name for such plants are 'mosses'. They belong to a group called **Bryophyta.**

Bryophytes are commonly called **amphibians of the plant kingdom**since they need water for completing the life cycle.

Like algae, here too plant body is **thallus**, Small unicellular root like extensions called rhizoids are present.

Bryophytes include two groups of plants namely, **liverworts** and **mosses.** Liverworts have a green plant body resembling the shape of liver. Eg. *Riccia, Marchantia*. In mosses the plant body grows vertical to the soil surface. Eg. Poly trichum, funaria.

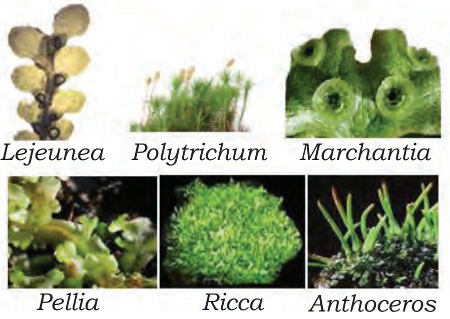

Lejeunea *Polytrichum* *Marchantia*
Pellia *Ricca* *Anthoceros*

Fig. 5.3 Some examples of Bryophytes

Bryophytes reproduce sexually. The life cycle includes two generations namely, a haploid **gametophyte** and a diploid **sporophyte**. The adult plant body is called gametophyte since it produces male and female gametes in distinct structures called **antheridia** and **archegonia** respectively. Gametophyte is photosynthetic and can lead an independent life. The zygote resulting from sexual reproduction develops into a diploid sporophyte.

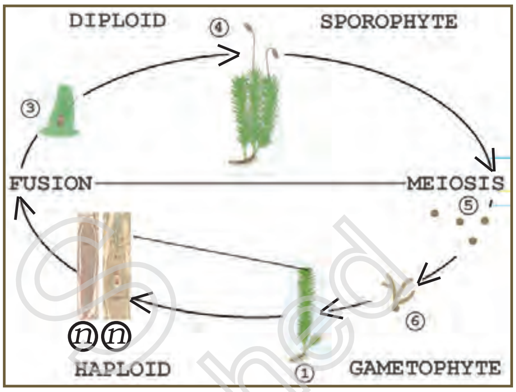


Fig.5.4
Life cycle of a Bryophyte

The sporophyte by meiosis produces haploid spores. These spores on germination give rise to a haploid gametophyte.

This process of gametophyte and sporophyte being formed alternately during the life cycle is called **alternation of generations.**

Know this

Mosses generally make their appearance after the rains. They grow on moist walls, tree trunks and on ground. Mosses growing in marshy places are called ***bog mosses****. They are abundant in our state, especially in the districts of Madikeri, Chikkamagalur, Hassan and Shivamogga.*

Economic importance

- Mosses are used in packing flowers.
- They are also used in pots for moisture retention
- Since mosses form a dense mat on the soil, they check erosion.
- Bryophytes can decompose the rocks (weathering) and contribute to soil formation.

Pteridophytes

Flower bouquets prepared or flower arrangements have small, green coloured artistic leaves between flowers that enhance their beauty. From which plants are these leaves taken? These are a variety of plants called **ferns** (**jari sasya** in kannada). They belong to a group called **pteridophyta**.

Pteridophytes are the first terrestrial plants to develop vascular tissues. Can you recall the types and functions of vascular tissues?

Recall that all plants containing vascular tissues are grouped under **tracheophytes**. They include Pteridophytes, Gymnosperms and Angiosperms.

Pteridophytes grow in moist soil, damp walls and in cool and shady places. The plant body shows distinct root, stem and leaves.

Eg. *Nephrolepis*, *Selaginella*, *Adiantum*, *Lycopodium* and *Marsilea*.

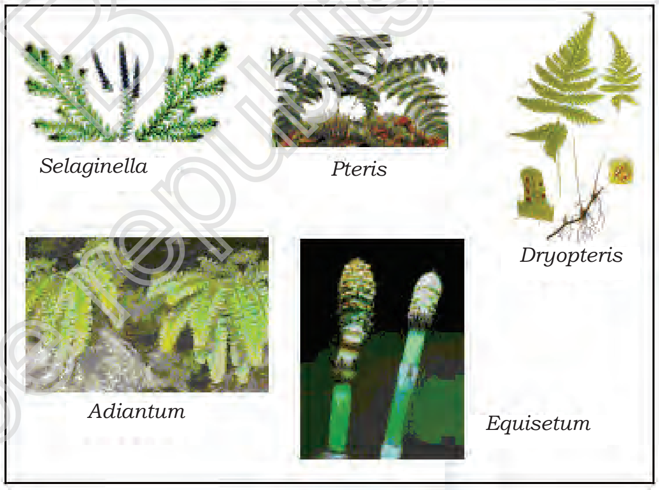


Fig 5.5 Some examples of Pteridophytes

The adult plant body in pteridophytes is a **sporophyte**(2n). It reproduces asexually by producing haploid spores. The spores germinate into a haploid **gametophyte**, called **prothallus**. It leads an independent existence. It reproduces sexually by producing male and female gametes in **antheridia** and **archegonia** respectively. The zygote resulting from the fusion of gametes, develops into a sporophyte. Thus, an **alternation of generations** is noticed in pteridophytes also.

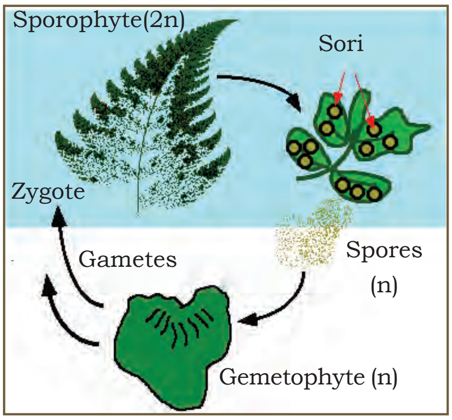


Fig 5.6
Life cycle of a Pteridophyte

Think

The adult plant body in Bryophytes is a haploid gametophyte while in pteridophyte it is a diploid sporophyte.

Know This

*There is a mention of these plants as **Jari sasya** in **Charaka samhita** and **Vrikshayurveda.***

The leaves of Adiantum, a fern, touch the ground develop roots and form new plants it is called walking fern.

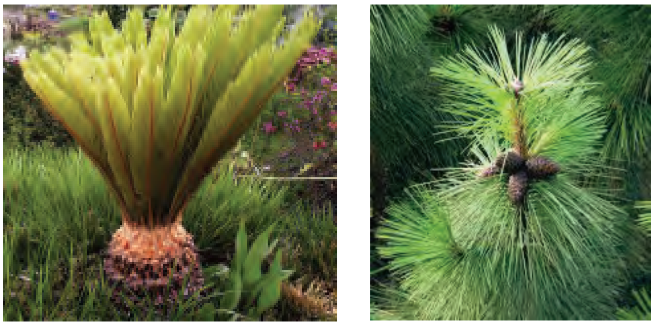
Economic importance

- Ferns are grown for their ornamental value.
- Leaves are used in making flower bouquet.
- Some ferns are of medicinal importance.
- Some ferns like horse-tails and club mosses are involved in the formation of fossil fuels like coal and petroleum.

Gymnosperms

You have seen many fruits like papaya, apple, jack fruit and water melon. Where do you find the seeds in them? Are not they enclosed in the fruit? Do you know that there are plants in which seeds are not enclosed in fruits? They are exposed. These plants belong to a group called **gymnospermae** (Greek: gymnos=naked, sperma=seeds). Hence, they are commonly called **naked seeded plants.**

Gymnosperms grow both in and on mountain tops at low temperature. They mostly comprise ever green trees. Some are bushy plants. Eg. *Cycas* and *Pinus*.



Cycas *Pinus*

Fig 5.7 Examples of Gymnosperms

The plant body is a sporophyte. It produces prominent structures called **cones**. There are **female cones** and **male cones**.

Male cones contain numerous **microsporophylls**, which produce **microspores** that have male gametes. Female cones contain **megasporophylls**, which produce **ovule** containing female gametes. The fusion product zygote, becomes the seed. There is no fruit.

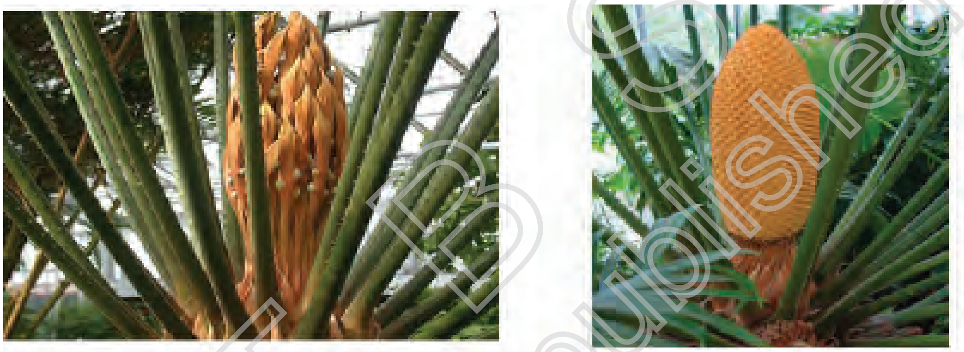


Fig 5. 8 Female cone and Male cone of Cycas

Know This

- Coniferous trees are the largest, tallest and the oldest trees of the world.
- It is believed that pine tree has a life span of more than 5000 years.
- The giant *Sequoia* grows to a height of about 100 meters with a circumference of more than 30 meters. In USA a road has been constructed by tunnelling the main trunk of a Sequoia tree!
- *Araucaria, Thuja,*(the chistmas tree*) Cupresscus* and *Cycas* are grown as ornamental plants.

Angiosperms

Majority of plants we see around us show a rich variety in their leaves, flowers and fruits and attract our attention These plants belong to a group called **angiospermae** (greek: angion=cover, spermae=seeds).In these plants seeds are enclosed in structures called **fruits.** Angiosperms are the most evolved group of plants.

The adult plant body is a sporophyte. It shows distinct root, stem and leaves. The most significant feature of angiosperms is the flower, which encloses the reduced gametophyte. It is the reproductive part of a plant. It may be found singly or in a cluster, called **inflorescence**.

Recall the structure of a flower.

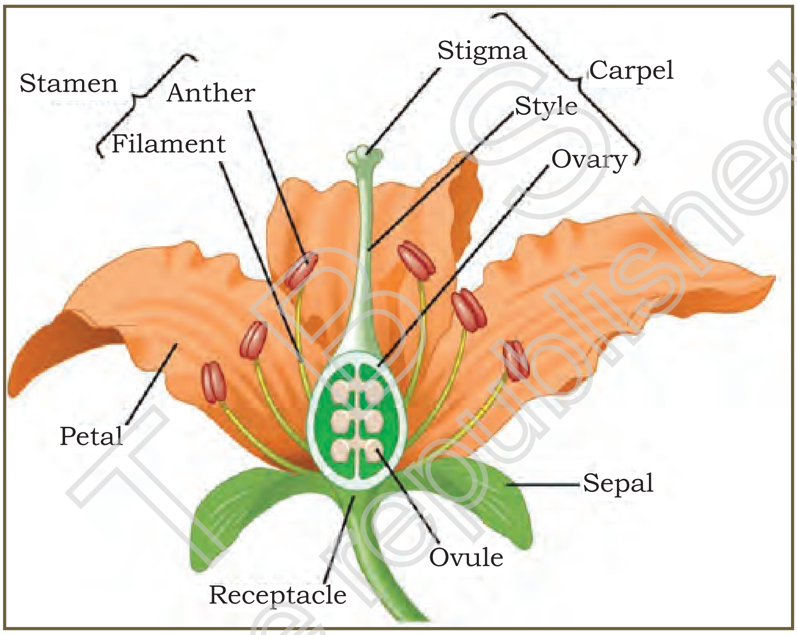


Fig 5.9 Parts of a flower

Angiosperms can be distinguished into two major groups namely, **monocots** and **dicots**. Let us find out the differences.

- In monocots the seeds contain only one cotyledon. Hence, they are called **monocotyledonous**. In dicots the seeds contain two cotyledons. Hence, they are called **dicotyledonous**. During germination, cotyledons remain below the soil in most of the monocots, while cotyledons appear above the soil in most of the dicots.

- Monocot plants have a **fibrous root system**. Here, the primary root is short lived. Roots develop from the base of the stem. Dicot plants have a **tap root system**. Here, the primary root continues to grow throughout the life of plant. It produces many secondary and tertiary branches.

- Monocot leaves have **parallel venation**. Dicot leaves have **reticulate venation**.
- In monocots, the floral whorls are found in multiples of three. In dicots petals are normally in multiples of four or five.

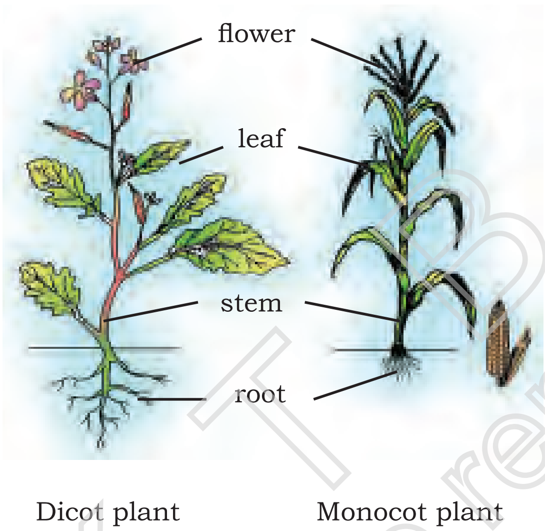


Fig 5.10
Angiosperm plants

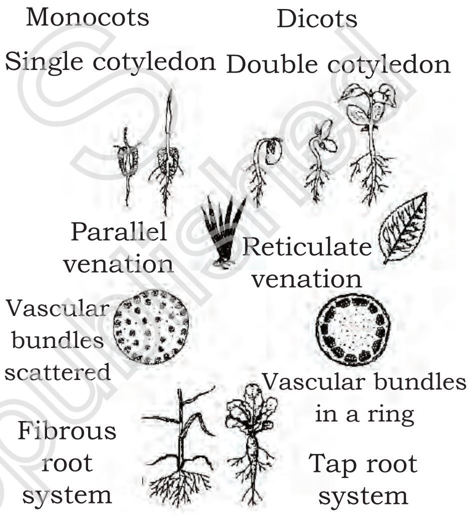


Fig 5.11 Differnces between monocots and dicots

Activity 5.1

Find out whether the different grains brought to your house are monocots or dicots.

Know this

Nearly 2,00,000 species of dicots and about 55,000 species of monocots have been identified so far.

India has a rich representation of angiosperms. More than 16,000 species of angiosperms have been identified.

The seeds of orchids are very small. About one million seeds put together weigh only about 0.3 grams.

Bonsai is a Japanese technique of dwarfing trees and growing them in pots. The trees grown like this remain in the same height even after 20 to 30 years. They even produce flowers and fruits.

Know this

Angiosperms are of immense economic importance. Following are a few of the useful plants.

Vegetable yielding plants

Cucumber, ladies finger, brinjal, onion, potato, carrot, beans, lemon, and green leafy vegetables .

Oil yielding plants

Ground nut, castor, palm, coconut , safflower, sunflower, and gingelly.

Spice yielding plants

Coriander, cumin, mustard, fenugreek, pepper, cardamom, clove, turmeric

Fruit yielding plants

Mango, grapes, apple, banana, guava, water melon

Fodder yielding plants

Maize, jowar, ragi, paddy, grasses

Fibre yielding plants

Cotton, jute, hemp, coconut

Beverage yielding plants

Coffee, tea, cocoa

Medicinal plants

Sarpagandha, Leucas, Tulsi, Neem, Eucalyptus, ginger

Activity 5.2

Find out about other plants in each of these categories and add to the list.

Know this

You are familiar with 'ayurveda', the ancient Indian system of medicine. The onset and growth of ayurveda was boosted by the flowering plants, since most of the medicines were derived from them. Aroma therapy, rasoushada, kashaya therapy and many such lines of treatments are purely based on administering herbal medicines.

HIGHER ANIMALS

You have studied in your previous class that multicellular animals are classified into **nonchordates** and **chordates**. Recall that all the animals from sponges to echinoderms do not have a supporting structure called **notochord** on their dorsal surface. There is only one phylum in which the examples are characterised by the presence of a notochord. This is **Phylum Chordata**. Members of this phylum are commonly called **chordates**. Let us now study the characters, classification and examples of chordates.

Phylum Chordata

Members of the phylum chordata exhibit the following three unique features

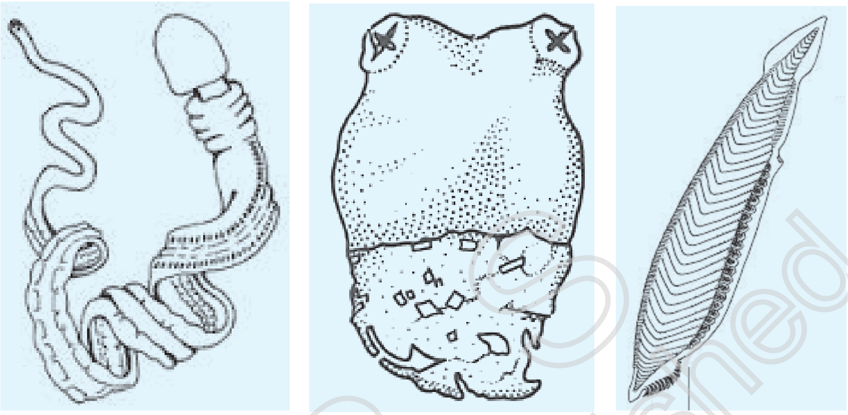
- Presence of a solid supporting structure on the dorsal side of the body, called **notochord**.
- Presence of a **dorsal, hollow, tubular nerve cord**
- Presence of openings in the pharynx called **gill slits**, atleast in the embryonic stages

Chordates in which the notochord gets replaced by a vertebral column in the embryonic stage, are called **vertebrates**.

Chordates are classified into four sub phyla namely;

- **Subphylum Hemichordata** : Here, the notochord is restricted to the anterior half of the body. Eg : *Balanoglossus*.
- **Subphylum Urochordata**: Here, the notochord is present only in the tail region of the larva. It is absent in the adults. Eg. *Herdmania* (sea squirt)
- **Subphylum Cephalochordata**: Here, the notochord is present through out the length of the body. Eg. *Amphioxus*

These three sub phyla are together described as protochordates (primitive chordates). All the examples are marine forms.



Balanoglossus Herdmania Amphioxus

Fig 5.12 Examples of Protochordates

- **Subphylum Vertebrata**: Here, the notochord is restricted only to the embryonic stage. In adults, it is replaced by a vertebral column. The examples are called **vertebrates**.

Know this

*Vertebral column refers to a structure containing a series of ring like bones called **vertebrae**, arranged one above the other. It is also known as **back bone**. It is an important part of the skeletal system, meant for supporting the body and providing attachment to the muscles.*

Vertebral column

Vertebrates

Vertebrates are the most advanced group of animals. They have a body divisible into head, trunk and tail. A well developed digestive system consisting of mouth, buccal cavity, pharynx, oesophagus, stomach, and intestines , along with many associated glands, is present. A **closed type** of circulatory system with a muscular chambered heart is present. Nervous system shows a well developed brain, spinal cord and nerves. All vertebrates are unisexual and exhibit only sexual reproduction.

Vertebrates are grouped into five classes, namely;

- Class Pisces (fishes)
- Class Amphibia (amphibians)
- Class Reptilia (reptiles)
- Class Aves (birds)
- Class Mammalia (mammals)

Class Pisces

Fishes are among the most colourful and diverse group of vertebrates. They are **exclusively aquatic**, both freshwater and marine forms. They are **cold blooded** animals. They show the following characteristic features.

- The streamlined body is divisible into head, trunk and short tail.
- Body has an exoskeleton composed of **dermal scales**.
- Locomotor structures are in the form of paired and unpaired extensions of the body, called **fins**. Paired fins help in balancing.
- Respiratory organs are in the form of **gills**. Gill slits may be exposed or covered by **operculum**.
- Heart is **two chambered**, with one auricle one ventricle. It receives and pumps only deoxygenated blood.
- Nervous system has a brain, a spinal cord and 10 pairs of cranial nerves.
- They are **oviparous** (egg laying) animals. Both fertilization and development are external.

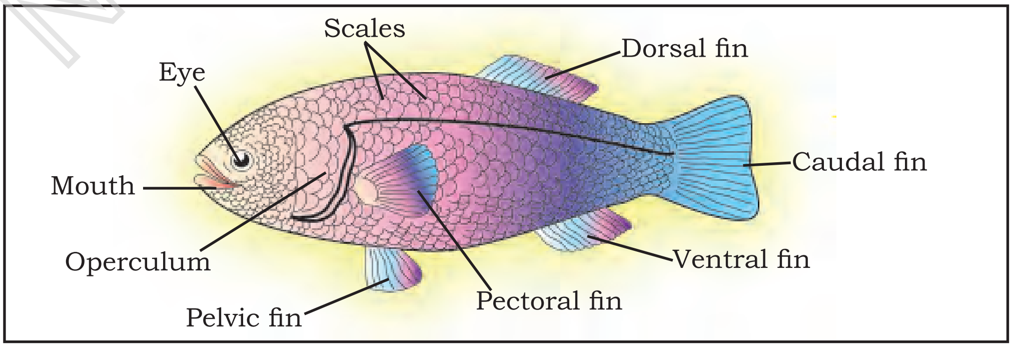


Fig. 5.13 External features of a fish

Based on the composition of the endoskeleton, fishes are classified into two major groups.

- **Cartilaginous fishes** : Only cartilages are found in the endoskeleton.

  eg. Sharks and ray fishes

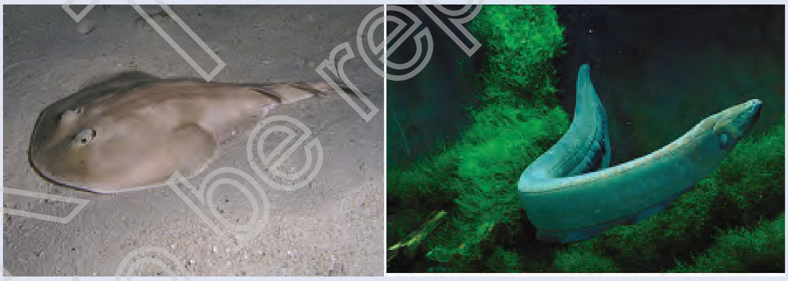
- **Bony fishes** : endoskeleton is composed of bones.

  eg. Hippocampus, carp, labeo

Know this

• Electricity producing fishes

Narcine, commonly called electric ray has a pair of organs which can produce upto 400 volts of current. The electric eel of Amazon can produce an upto 200 volts current.



Narcine Electric Eel

Fig. 5.14 Electricity producing fishes

• Strange fishes

Hippocampus, commonly called 'sea horse', does not resemble a fish. It has a snout resembling that of a horse. It has an elongated body and a long coiled tail. It is the only fish that swims vertically! The male Hippocampus has a brood pouch into which the female releases the eggs. After fertilizing these eggs the male has to take care of them, carrying them wherever he goes, till they hatch out!

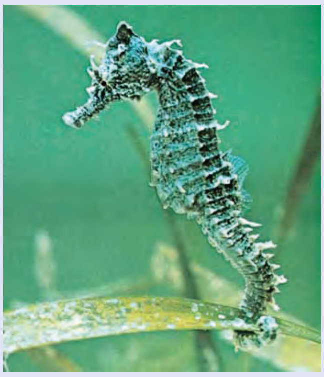


Fig. 5.15 Hippocampus

A fish called Ostracion, has a pair of horns in front of the head. Hence, it is commonly called cow fish.

A fish called Exocoetus, periodically takes a dive out of water for a few seconds and swiftly dives back into water. It is commonly called flying fish.

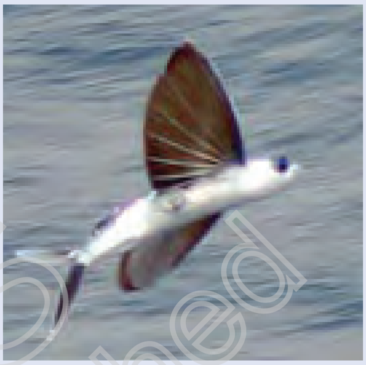


Fig. 5.16 Exocoetus

Economic importance

- Fishes form a favourite human food in many countries. Rearing of fishes for this purpose is called **pisciculture**.
- Oil obtained from the liver of sharks and cods is rich in vitamins A and D.
- The dried skin of sharks is used in making polishes.
- Fishes like *Gambusia* are used in the biological control of mosquitoes, since they feed on the larvae of mosquitoes.

Class Amphibia

Members of this class called amphibians, represent the first vertebrates to appear on land. They show adaptations to live both in water and on land. Amphibians are also **cold blooded** vertebrates. They show the following characteristic features.

- The body is divisible into head, trunk and tail. A tail may be absent in the adult stage.
- There is **no exoskeleton**. Skin is smooth and moist.
- Locomotor structures are in the form of a pair of **fore limbs** (with **four** digits each) and a pair of **hind limbs** (with **five** digits each).
- Respiratory organs are **gills** in the larva and a pair of lungs in the adult. Skin also helps in respiration.

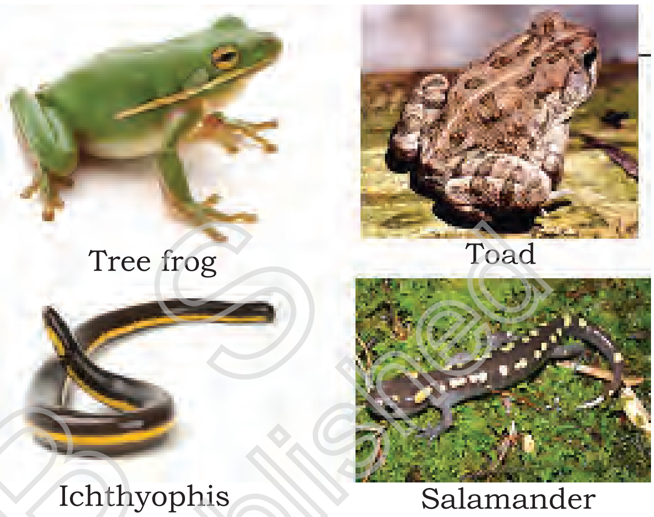

Tree frog
Toad
Ichthyophis
Salamander

Fig. 5.17 Common Amphibians

- Heart is **three chambered**, with two auricles and one ventricle. It receives both oxygenated and deoxygenated blood.
- Nervous system has a brain, a spinal cord and ten pairs of cranial nerves.
- They are **oviparous**. Fertilization and development are both external. Development may include a process of transformation of the larva into adult. It is called **metamorphosis**.
- Eg: frog, toad, salamander, newt, Ichthyophis (apodan).

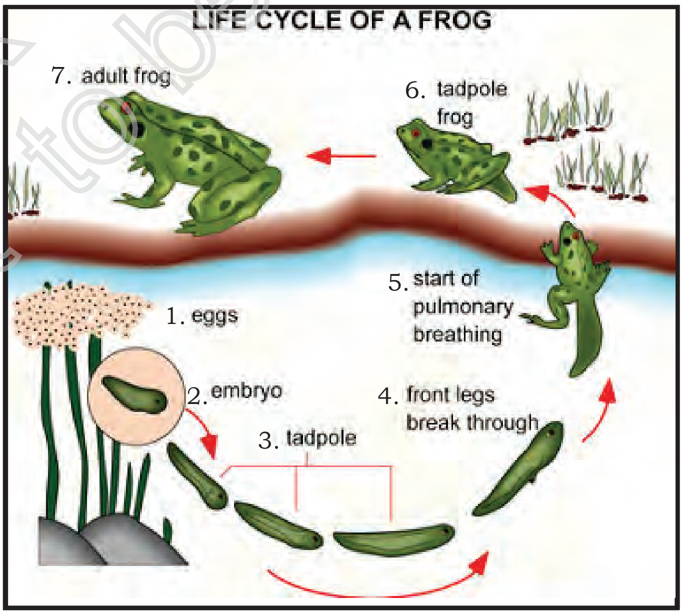


Fig. 5.18 Life cycle of Frog

Know this

- Frogs and toads do not have a tail in the adult stage. Their hind limbs are longer than fore limbs enabling them to hop.
- Salamanders and newts have a tail even in the adult stage. They resemble lizards.
- Apodans are limbless amphibians with a long snake like body. Their eyes are non-functional and hence, they are commonly called blind worms.

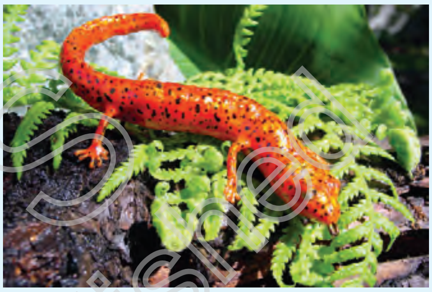


Fig. 5.19
Tiger salamander

- Some amphibians are known for exhibiting parental care. A toad called *Alytes* carries the eggs laid by the female on its back till they hatch out. it is commonly called mid-wife toad. Another toad called *Pipa*, carries the eggs in numerous pockets on the back. *Ichthyophis* remains coiled around the eggs till they hatch into young ones.

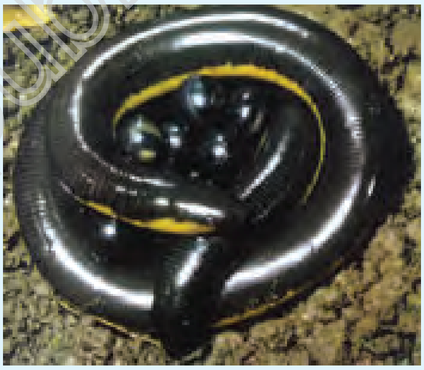


Fig. 5.20 Ichthyophis coiling around its eggs

- Some frogs and toads remain buried for weeks together in damp places to avoid extremes of temperature. This is called **hibernation** (winter sleep) and **aestivation** (summer sleep).

Class Reptilia

Members of this class called reptiles, are the first true terrestrial vertebrates. Most of them are land forms. Some are secondarily adapted for a life in water. Reptiles are also cold blooded vertebrates. They exhibit the following characteristic features.

- The body is elongated, divisible into head, trunk and tail.
- The exoskeleton is in the form of epidermal scales, forming distinct plates.

- Locomotor structures are in the form of a pair of fore limbs and a pair of hind limbs, containing five digits each (**pentadactyl** condition).
- Respiratory organs are a pair of **lungs**.
- Heart is **three chambered**. Only in crocodiles ventricle is incompletely divided into two chambers.
- Nervous system has a brain, a spinal cord and 12 pairs of cranial nerves.
- They are **oviparous**. Fertilization is internal but development is external.

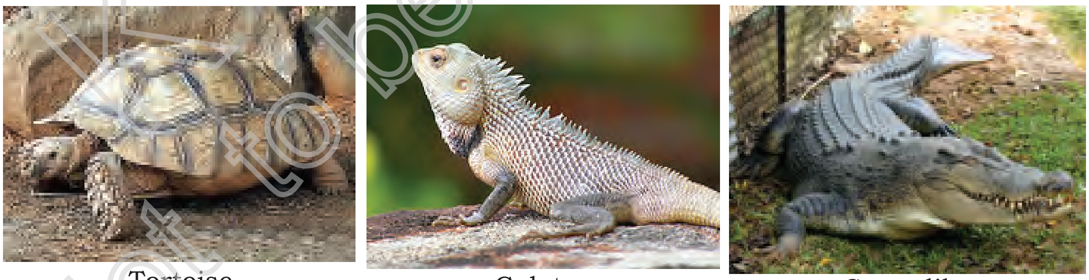
Common examples: Reptiles are identified in four groups, namely;

Chelones : Turtles and tortoises

Lizards : House lizard, Chamaeleon, Calotes (garden lizard), Varanus (monitor lizard), Draco (flying lizard).

Snakes : Viper, Cobra, Sea snake, Krait, Dryophis, Python

Crocodiles and alligators


Tortoise Calotes Crocodile

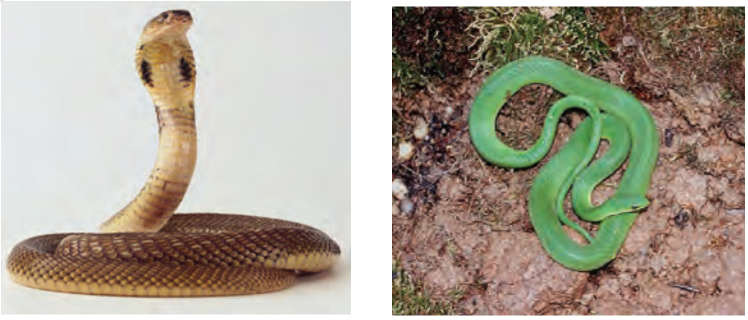

Cobra Dryophis

Fig. 5.21 Common Reptiles

Know this

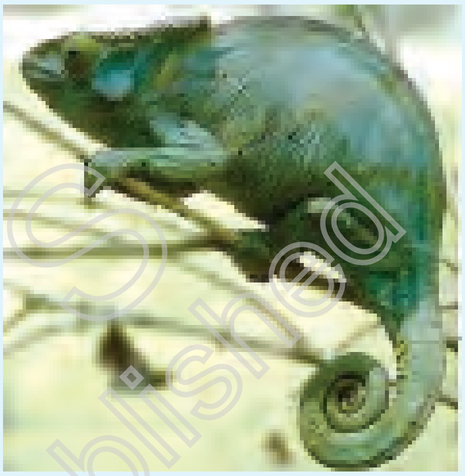


Fig. 5.22 Chamaeleon

- Chameleon is known for its ability to change its body colour. It moves its two eyes independently.
- ***Varanus*** is one of the biggest among lizards. It is known for its grip on any kind of surface. It is said that soldiers in the court of many kings in India were using Varanus to climb the tall fort walls.
- ***Tuatara,*** a lizard found in New Zealand, is an example of a living fossil
- Tortoises are among the longest lived animals. There are instances of tortoises having lived for nearly 200 years.
- Of the more than 300 species of snakes identified, only 6 are poisonous!

Know this

Do crocodiles really shed tears ?

Periodically, crocodiles eliminate some nitrogenous wastes in a dissolved state through a pair of glands situated near their eyes. It is this process which appears as shedding of tears.

Extinct reptiles

You have read about dinosaurs. They were a group of huge reptiles which ruled the Earth about 150 millions of years ago. It was much before the arrival of mammals on the Earth.

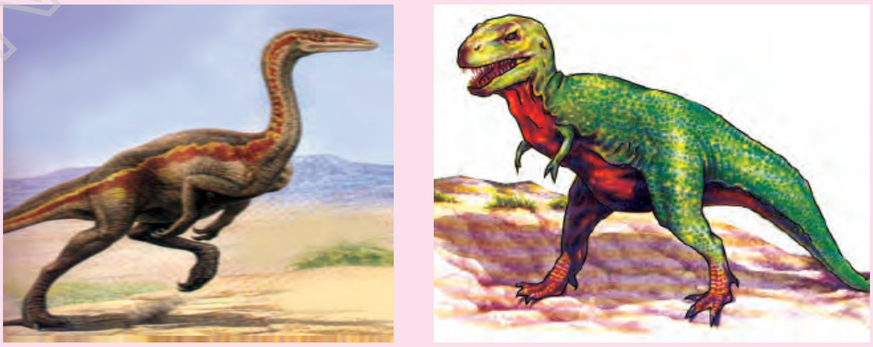


Fig. 5.23 Dinosaurs

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Think

Is there any relationship between warm blooded condition and four chambered heart?

Know this

Cold blooded and warm blooded condition

Vertebrates that keep changing their body temperature according to the changes in the environment are called ***cold blooded*** *or* **poikilothermic** *animals. Fishes, amphibians and reptiles are poikilothermic.*

Vertebrates that maintain a constant body temperature, irrespective of changes in the environmental temperature, are called ***warm blooded*** *or* ***homeothermic*** *animals. Birds and mammals are homeothermic.*

Oviparous and viviparous condition

Animals which lay eggs are generally described as ***oviparous****. In oviparous animals both fertilization and development may be external as in fishes and amphibians. On the other hand, fertilization may be internal but development may be external, as in reptiles and birds.*

Animals which give birth to young ones, are called ***viviparous****. Here, both fertilization and development take place inside the body of female parent, as in mammals.*

In many of our ancient scriptures, dating back to thousands of years, animals have been classified into ***andaja*** *(developing from eggs) and* ***jarayuja*** *(developing in the placenta)!*

Think

How do you think the shift from cold blooded conditions to warm blooded conditions and the shift from oviparity to viviparity has helped vertebrates?

Class Aves

Members of this class commonly called birds, represent a highly specialized and diverse group of vertebrates. They are mostly aerial, capable of flying. Some examples are aquatic. Unlike the fishes, amphisbians and reptiles, birds are warm blooded. They exhibit the following features.

- The body is streamlined, boat shaped, and is divisible into a head, a trunk and a tail.
- The exoskeleton is represented by epidermal outgrowths called **feathers**. They provide protection, maintain body temperature, help in flight and attracting the opposite sex.

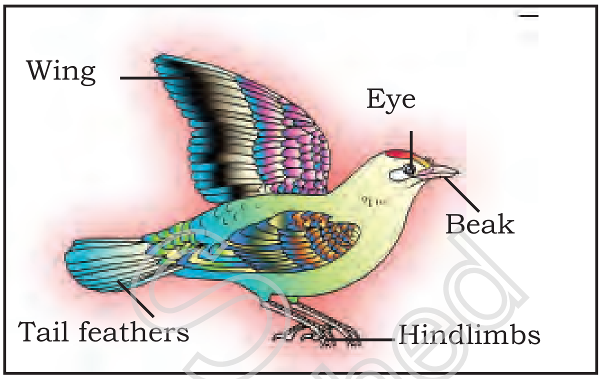


Fig 5.24 External features of a bird

- Locomotor structures are **pentadactyl** fore limbs and hind limbs. Fore limbs are modified into wings for flying.
- Respiratory organs are a pair of lungs.
- Heart is **four chambered**, with two auricles and two ventricles. There is complete separation of oxygenated and de oxygenated blood. Aortic arch is on the **right side**.
- Brain is well developed. 12 pairs of cranial nerves are present.
- They are **oviparous**. Fertilization is internal and development is external.

Birds can be classified into two groups, namely;

Flying birds: Parrot, hawk, pigeon, crow, sparrow, swan, duck and flamingo.

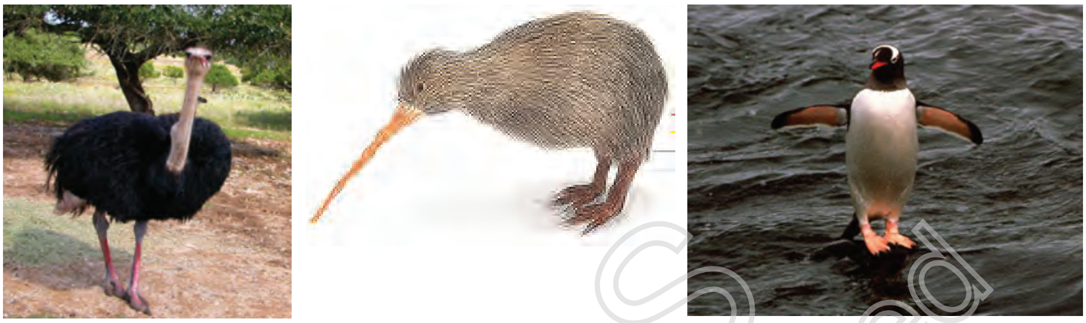
Flightless birds : Ostrich, Kiwi, Rhea, Emu, Penguin etc.

Humming bird

Pea cock

Eagle

Fig. 5.25 Some flying birds



Ostrich Kiwi Penguin

Fig. 5.26 Some flightless birds

What enables a bird to fly?

- *Streamlined body.*
- *Forelimbs modified into wings.*
- *Special arrangement of feathers on the wings to provide the lift.*
- *Presence of flight muscles.*
- *Reduced body weight.*
- *Long bones are pneumatic, filled with air.*
- *Many bones in the body are fused.*
- *Absence of teeth, replaced by a beak.*
- *Lungs are supported by air sacs for storing additional air.*

Know this

- *Humming bird is the smallest bird, weighing just about 3 grams!. It is an active flyer. It can also fly backwards*
- *Ostrich is the biggest bird. A male ostrich is about 2.4 meters in height and weighs about 140 kg. It can run at a speed of about 80 kmph.*
- *Arctic tern, a migratory bird, can make a nonstop flight covering a distance of more than 18,000 km.*
- *Male birds have a colourful arrangement of feathers (called plumage) to attract the females. Peacock is an example for this.*

Class Mammalia

Mammals, the members of this class, represent the most advanced group of vertebrates. They occur in a variety of habitats. Most of them are terrestrial, some are aquatic and a few are aerial. They are also **warm blooded**, like birds. Mammals exhibit the following characteristic features.

- The body is divisible into head, trunk and tail. Trunk is divided into an upper thorax and a lower abdomen, separated by a muscular membrane called diaphragm.
- The exoskeleton is represented by epidermal outgrowths called, hairs.
- Locomotor organs are typical **pentadactyl** fore limbs and hind limbs,with digits ending in claws or nails.
- Respiratory organs are a pair of **lungs**.
- Heart is **four chambered**. Aortic arch is on the **left side.**
- RBC are **enucleate** at maturity, except in camels.
- Teeth are of different types (**heterodont**), embedded in sockets in jaw bones (**thecodont**), and occur in two sets during life (**diphyodont**).
- Brain is well developed. 12 pairs of cranial nerves are present.
- They are generally **viviparous**. Both fertilization and development take place inside the body. A **placenta** is present to nourish the embryo.
- **Mammary glands** are present in females secrete milk to nourish the young ones.

Following are the major groups of mammals.

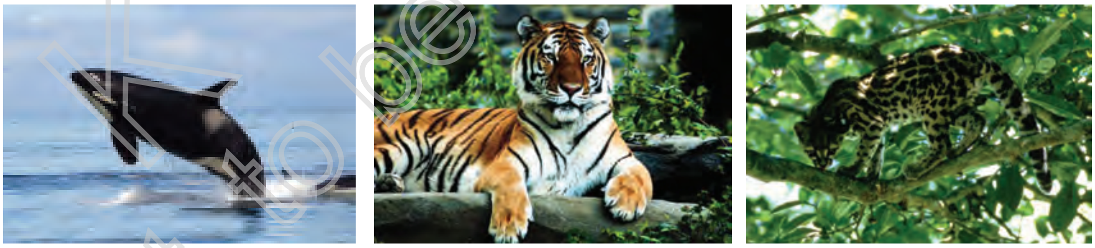
1. Egg laying mammals: Platypus and echidna

2. Pouched mammals : Kangaroo, Opossum

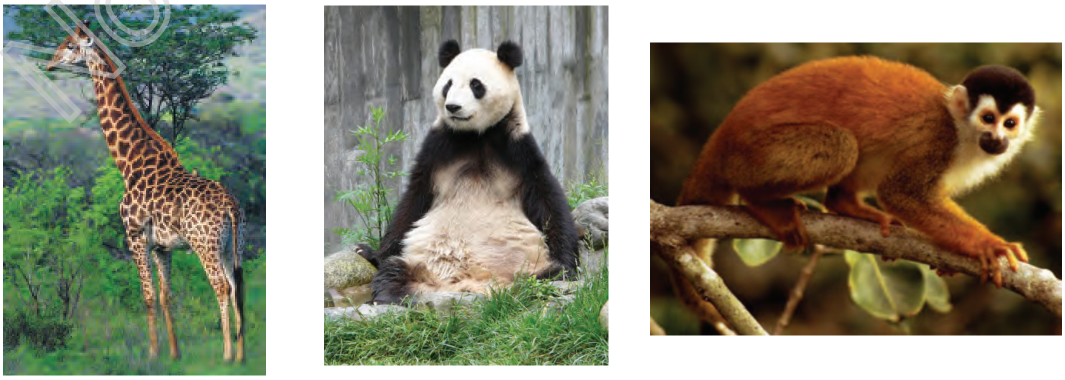
3. True Placental mammals

- Flying mammals : Bats, lemurs
- Aquatic mammals : Whales (largest among animals) and Dolphins
- Carnivorous mammals : Lion, tiger, panther, cat, dog, wolf, fox
- Herbivorous mammals : Horse, cow, donkey, camel, giraffe, Elephant (Largest land animal)
- Burrowing form : Rats, rabbits, squirrels, shrews
- Primate : Monkeys, apes and humans

Platypus Echidna Kangaroo



Dolphin Tiger Panther



Giraffe Panda Monkey

Fig. 5.27 Some examples of Mammals

Know this

- **Pigmy shrew** is the smallest mammal, weighing only about 2.5 g
- **Blue whale** is the largest mammal, and the largest of all animals. It is about 30 meters long and about 200 metric tons in weight.
- **Kangaroo**, the national animal of Australia, has a pouch on its lower abdomen to carry the immature young ones.
- A tree living mammal called **sloth**, walks and even sleeps upside down
- **Bats** are the only mammals capable of true flight. They have a unique mechanism called echolocation in which reflected sound waves help in directing the movement. This mechanism forms the basis for radars and sonars.
- **Beavers** are known for their architecture. Using stones and tree trunks, they construct dams and reservoirs in rivers.

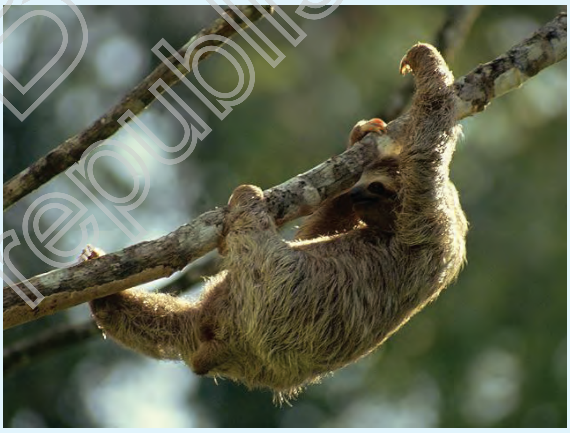


Fig. 5.29 Sloth

Exercise

I. Choose the correct answer from those given, for the following questions

1. Identify an example of red algae from the following

a. Polysiphonia	c. sargassum
b. Spirogyra	d. ectocarpus

2. The adult plant body is a gametophyte in

   a. Angiosperms c. gymnosperms

   b. Pteridophytes d. bryophytes

3. Identify the feature exclusive to monocots

   a. tap root system c. reticulate venation

   b. fibrous root system d. flowers with 4 or 5 petals

4. Among vertebrates, notochord is

   a. found only in the anterior half

   b. found only in the larval stage

   c. found throughout the body

   d. replaced by a vertebral column

5. In reptiles the heart is

   a. Two chambered

   b. Incompletely four chambered

   c. three chambered

   d. four chambered

6. Identify the pair of oviparous vertebrate groups where fertilization and development are both external

   a. Fishes and amphibians c. amphibians and reptiles

   b. Reptiles and birds d. birds and mammals

7. The skin in amphibians has

   a. An exoskeleton of scales c. an exoskeleton of hairs

   b. No exoskeleton d. an exoskeleton of feathers

8. Identify the odd one

   a. Calotes c. chameleon

   b. Salamander d. varanus

9. Aortic arch in birds is

a. On the right side   c. on the left side

b. On both the sides   d. absent

10. Identify the character not found in mammals

a. Enucleate RBC   c. viviparous condition

b. All similar teeth   d. presence of mammary glands

IV. Fill in the blanks with suitable words.

1. The pigment responsible for red colour in red algae is ______________ .

2. Ulothrix is an example of____________ .

3. The respiratory organs in fishes are ____________.

4. Among reptiles, the heart is incompletely divided into four chambers Only in___________

5. _________ is an example of limbless amphibian

IV. Name the following.

1. Amphibians of the plant kingdom

2. Reproductive structures in gymnosperms

3. Membrane separating thorax and abdomen in mammals

4. An aquatic flightless bird

5. The largest lizard

V. Match the names of the animal groups in column I with the examples given in column II

Column I	Column II
1. Mammalia	a. amphioxus
2. Aves	b. carp
3. Reptilia	c. newt
4. Amphibia	d. tortoise
5. Pisces	e. ostrich
	f. whale

V. Answer the following questions

1. Make a list of the salient features of brown algae
2. Explain alternation of generation with reference to gymnosperms
3. Write a brief note on cones in gymnosperms
4. Describe the economic importance of ferns
5. Distinguish between monocots and dicots
6. Make a list of the unique characters of phylum chordata
7. Make a list of any four unique features of fishes
8. Name the major groups of reptiles with an example for each
9. Make a list of the main flight adaptations in birds
10. Give an example for each of the following
    a. flying mammal
    b. largest animal
    c. egg laying mammal
    d. pouched mammal
    e. largest land animal
    f. carnivorous mammal
    g. herbivorous mammal
    h. primate

CHAPTER 6

PLANT AND ANIMAL TISSUES

After studying this chapter you

- define the term tissues.
- classify plant tissues.
- learn about the types and functions of meristematic tissues.
- learn about the simple and complex permanent tissues.
- classify animal tissues.
- understand the types, location and function of epithelial, muscular and connective tissues.
- understand the structure of a neuron.

You are already aware that organisms are classified on the basis of number of cells into **unicellular** and **multicellular** organisms. Recall examples like Amoeba and Paramecium. They have a single cell representing the body. In multi-cellular animals or plants the body structure is more complex. They are composed of groups of cells which are specialized for performing specific functions.

A group of cells which have a common origin, structure and function, constitute a **tissue**.

Tissues show a great variety in their structure, like shape of the cells, thickness of cell walls, and other characteristics. Each tissue performs a specific function, and a group of such tissues which coordinate to perform a particular function is called an **organ**. A group of organs performing a set of functions, is called an **organ system**.

Know this

*The branch of biology which deals with the study of tissues and their organization is called **histology**.*

Plants exhibit only tissue level of organization. There are no organs and organ systems.

Let us now study different types of tissues in plants and animals.

In Angiosperms, there are different tissues to perform different functions such as growth, absorption, photosynthesis, protection and conduction of water and minerals.

Plant tissues are classified into two major groups on the basis of function. They are, **meristematic tissue** and **permanent tissues**.

Plants keep growing till they die, because they have tissue meant only for growth, called **meristematic tissue**. It is composed of cells which keep on dividing forming new cells. Where does it occur? Of course, in the growing regions like root tip, stem apex, and buds.

We observe two types of meristematic tissue; **apical** and **lateral**. Apical meristem is located at the shoot tip which makes the plant, grow taller and lateral meristem adds to girth of the plant body.

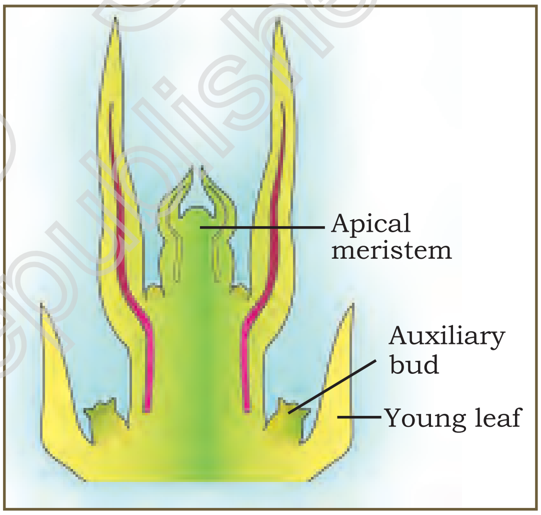


Fig. 6.1 Section through shoot tip showing meristem

Know this

Bamboo is the tallest grass and not a tree. It grows to a height of about 35 m and has a thickness of about 30 cm. It grows faster, about 40 cm in a day. The plant dies once blossoms.

Cells of the meristematic tissues show the following features:

- The cells have thin walls.
- The cells divide actively and cause growth.
- The cells are closely arranged without any inter cellular spaces in between.

- The cells have a large nucleus, lack chloroplasts.
- Vacuoles are either very small or absent.

Meristematic cells are also found in the vascular bundles of roots and stems where they bring about growth in thickness. They are also found at the nodes between leaves and the stem where they bring about branching.

All the permanent tissues are derived from cells formed by division of meristematic cells.

Permanent tissues

These are tissues formed by mature or specialized cells. The cells have a cellwall composed of cellulose. In addition, hemicellulose, pectin and lignin may also be present. Cells contain well developed plastids and other cell organelles. Vacuoles are large and prominent. Nucleus may be present or may not be present at maturity, in certain types.

Permanent tissues are of two types, namely :

Simple tissues and complex tissues.

Simple permanent tissues

In simple tissues all the cells are of the same kind, performing common functions. They form a major part of the plant body and take up several functions like storage and support.

There are three types of simple tissues, namely :

1. Parenchyma
2. Collenchyma
3. Sclerenchyma

Parenchyma

You might have felt the softness of flowers and certain leaves. This is due to the presence of parenchyma. It is found in soft parts of the plant like root, stem, leaf.

The cells of parenchyma tissue are composed of thin walled living cells.

They are least specialized out of all the simple tissues. The parenchyma cells vary in shape like round, elongated, polygonal or irregular. Generally cells are loosely arranged and contain large amount of food materials since they perform storage functions.

If Parenchyma cells contain chloroplasts it is called chlorenchyma and it takes part in photosynthesis

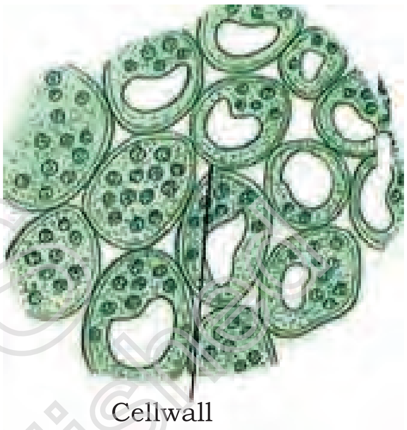


Fig. 6.2 Parenchyma

In aquatic plants like Pistia and lotus, you have seen leaves floating in water. What makes them float? Here, the parenchyma cells are loosely arranged with large intercellular spaces filled with air. Such a parenchyma is called **aerenchyma**.

Collenchyma

Collenchyma contains living cells and are capable of cell division. The cells are closely arranged without any spaces in between and are thick walled where they join. The cell wall is made up of hemicellulose or pectin.

They generally occur in pedicel and petiole. It provides mechanical support and flexibility to the regions where they occur.

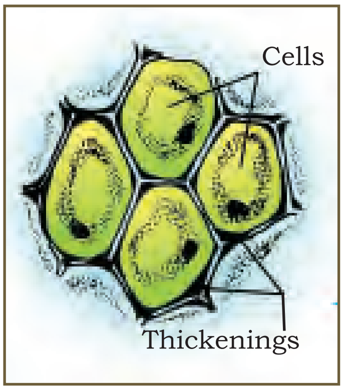


Fig. 6.3 Collenchyma

Sclerenchyma

Look at coconut. The hard shell of coconut is composed of a specialized simple tissue called **sclerenchyma**. It consists of thick, elongated cells, which are dead at maturity. The living cells of this tissue get deposited by lignin and lose nucleus and cytoplasm at maturity.

Sclerenchyma has two types of cells namely, **fibres** and **sclereids**.

The cellwall of sclerenchyma cells in plants like jute and hemp contain elongated, thread like thick walled cells called **fibres**.

Since the fibres are flexible and elastic they are used in coir industries to make gunny bags and ropes.

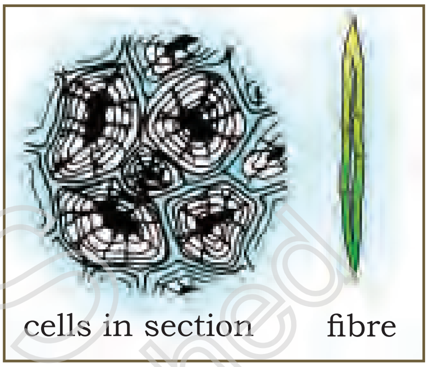


Fig. 6.4 Sclerenchyma

Sclereids are hard cells found in groups. They have more lignin than fibres. Hence they are commonly called **stone cells**. The cells may be isodiametric or columnar or bone shaped or star shaped. They are generally found in fruit wall and seed coats.

Complex permanent tissues

Complex permanent tissues comprise both living and non-living cells. The cells are of different kinds and they are closely arranged. There are two types of complex permanent tissues. They are water conducting (xylem) (phloem) and food **conducting tissues** or **transport tissues**. Hence, together they are also called **vascular tissues**.

Xylem

Xylem is a vascular tissue which transports water and minerals absorbed by the roots, to all parts of the plant, especially to the leaves. Hence, it is called **water conducting tissue**. This tissue also provides mechanical strength to various parts of the plant body. Hence, it is not so easy to break a branch of a plant.

Xylem tissue is composed of xylem parenchyma, xylem fibres, xylem vessels and tracheids.

Xylem vessels and trachieds are specially modified for conducting water and minerals.

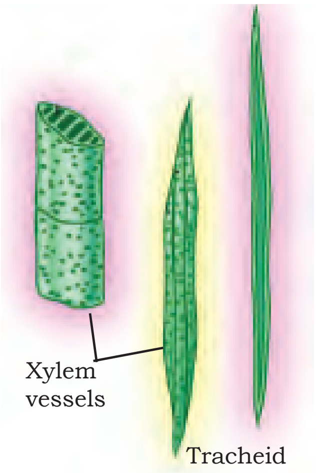


Fig. 6.5 Xylem

Xylem vessels consist of series of elongated dead cells joined together from end to end forming tube like structures that are suitable for quick conduction of water and salts.

Xylem tracheids are short structures, usually found at the leaf tip.

Phloem

Phloem is a complex tissue which conducts food to different parts of the plant. It is composed of four types of cells, Sieve tubes, companion cells, phloem fibres and phloem parenchyma.

Sieve tubes play an important role in the conduction of food. Sieve tubes comprise longitudinally arranged cells. The cells are joined end to end in a series. At maturity the cells do not have nucleus. A plate like structure with a number of minute pores is present in between two cells. It is called **sieve plate**. The food passes through these pores in the sieve plate.

There are certain cells closely associated with sieve tube, called **companion cells**. They are living cells which regulate the passage of food through sieve tubes.

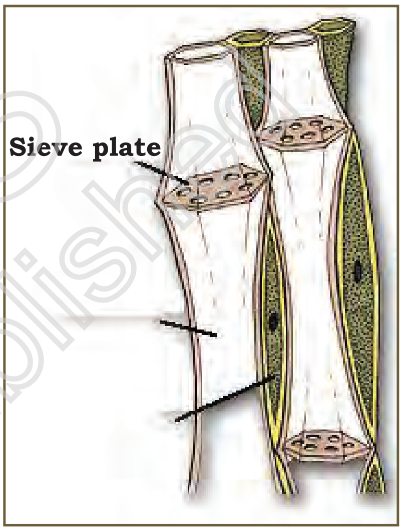


Fig. 6.6 Phloem

Think

Each sieve tube cell and its neighbouring companion cell are called sister cells. Why?

Dermal tissue

The outermost covering of all parts of a plant – stem, leaves, flowers, fruits, seeds and roots – is formed by protective tissue called **dermal tissue**. It is commonly called **'skin of the plant body'**. It is called **epidermis** and is made up of parenchyma cells. It is usually alive, only one cell thick. It is the outer protective tissue in young plants and mature non-woody plants. In woody plants, the epidermis is replaced by dead cork cells arranged in several layers which is also protective in function.

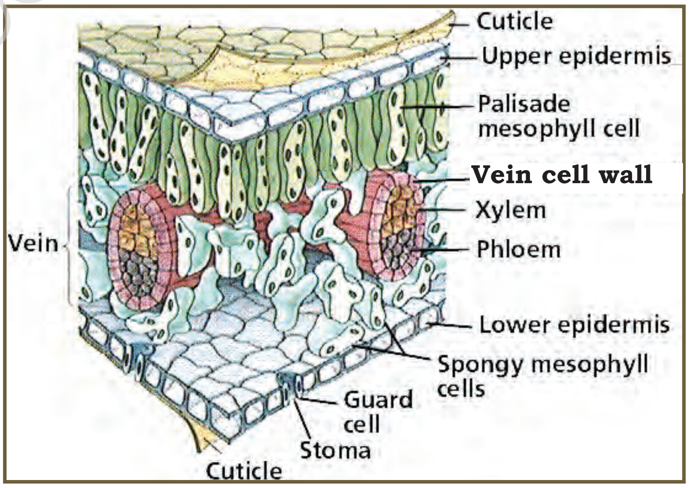


Fig. 6.7
Section of leaf showing dermal tissue

Dermal tissue has different functions, depending on its location in the plant.

- Above the ground, it prevents the plant from drying out by reducing water loss from evaporation (transpiration). Some plants like ivy, cabbage, banana etc. Secrete a waxy coating called cuticle to prevent water loss.
- Epidermis of the root, forms root hairs that absorb water and nutrients.
- In the leaves and stems, openings in the epidermis called stomata regulate the passage of gases such as oxygen and carbon dioxide and moisture into and out of the plant.

Activity 6.1

Observe the permanent tissues under microscope in the laboratory.

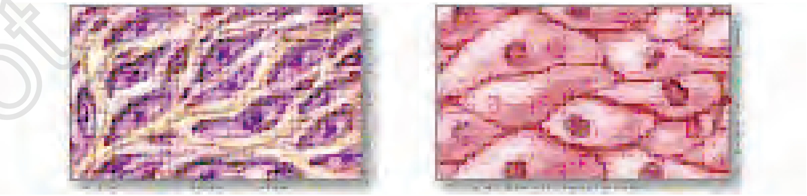
Think

You might have observed the aquatic plants like lotus. In such plants the cuticle is thick. Can you think why?

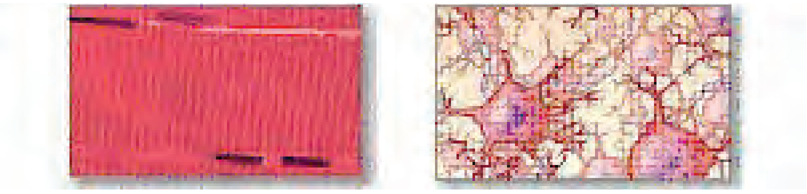
ANIMAL TISSUES

There are four basic types of tissues in animals;

1. Epithelial tissue
2. Muscular tissue
3. Connective tissue and
4. Nerve tissue



Connective tissue Epithelial tissue



Muscular tissue Nerve tissue

Fig. 6.8 Types of animal tissues

Epithelial tissue

It is the simplest among animal tissues. It is found lining the body parts, both internally and externally. The cells are always found resting on a basement membrane. They are compactly arranged, without any intercellular spaces.

Epithelial tissue is of the following types

When the cells are polygonal and flat, it is called **squamous epithelium**. When observed carefully, they look like the tiles on a floor. Hence, it is also called **pavement epithelium**. It is found in structures related to respiration and blood circulation like, alveoli of lungs, oesophagus, blood vessels, capillaries and inside the chambers of heart. It permits materials to diffuse through it. Whenever epithelium is found lining from inside, it is called **endothelium.**

Epithelium containing elongated cells is called **columnar epithelium**. Cells appear tall, narrow and column like or pillar like. It is found lining the alimentary canal and some glands. It is found in organs related to secretion, digestion and absorption.

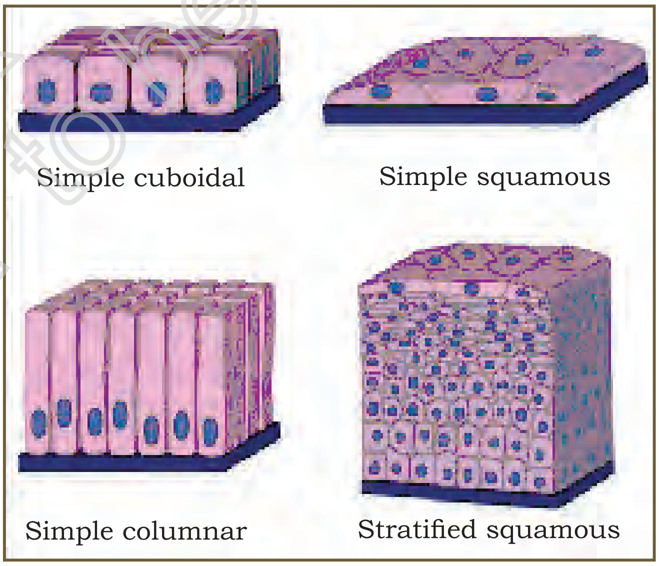

Simple cuboidal
Simple squamous
Simple columnar
Stratified squamous

Fig. 6.9 Types of epithelial tissue

Epithelium consisting of cube shaped cells is known as **cuboidal epithelium**. They form the lining for many ducts such as pancreatic duct, salivary duct and sweat ducts. In glands it helps in secretion. For example, salivary glands and thyroid gland.

When the columnar epithelial cells contain cilia on their free surface, it is called **ciliated epithelium**.

Functions of epithelium

- Epithelium forms a thick tough barrier and protects the underlying tissues in the skin. Epithelium of the skin also helps in maintaining a constant body temperature.
- Epithelium in sense organs, contain receptor cells.
- The movement of materials is assisted by ciliated epithelium.
- Epithelium also helps in absorption of nutrients and in excretion.

Muscular tissue

Muscular tissue is concerned with movements of the body. It is made up of elongated cells, hence, they are called **muscle fibres** or **myofibres**. The muscle fibres are specialized cells capable of contraction and relaxation. This property is responsible for movement of limbs and bending of the body. The movement of internal organs like heart, stomach and alimentary canal are also caused by muscles.

They are of three types, based on structure, function and location. They are ;

1. Striped muscles
2. Unstriped muscles
3. Cardiac muscles

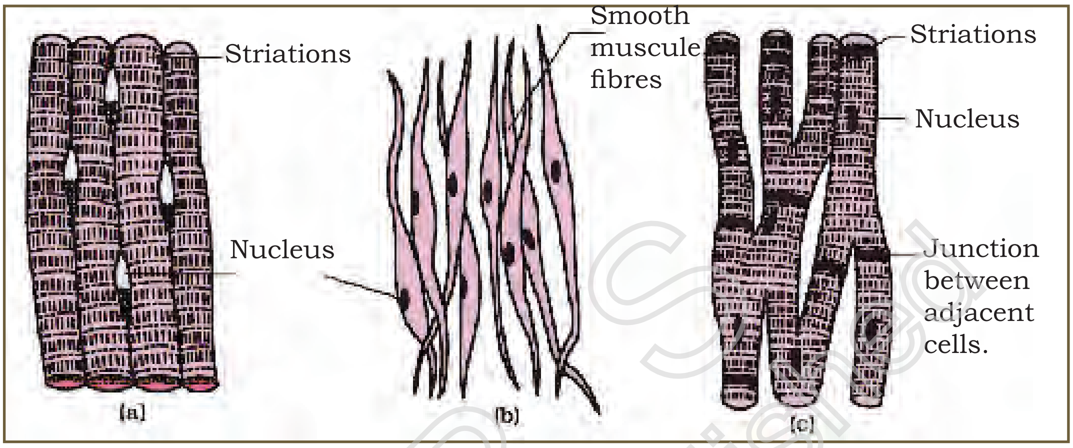


Fig. 6.10 Muscular tissue
a. striped muscles b. unstriped muscles c. cardiac muscles

Striped muscle

Here, muscle fibres are elongated, cylindrical and unbranched. They show characteristic striations or cross bands. Hence, they are also known as **striated muscles**. The muscle fibres are multinucleate. The striped muscles are usually attached to the bones and hence, are also known as **skeletal muscles**. They are Voluntary muscles and are responsible for locomotion. These muscles fatigue easily.

Unstriped muscles

Unstriped muscles are made up of spindle shaped, elongated muscle fibres without striations (cross bands). They are also called **smooth muscles**. A number of muscle fibres are held together by a membrane to form bundles called **muscles**. Fibres are uninucleate. The peristaltic movements of oesophagus, intestine and stomach are due to these muscles. Smooth muscles are found in the wall of the body cavity. They are also found in kidneys, blood vessels and glands. Since their movements cannot be controlled by our will, these muscles are called **involuntary muscles**.

Cardiac muscles

These muscle fibres are elongated, cylindrical and branched. The branches are connected with one another. They are involuntary muscles known for highly rhythmic contractions and relaxations. They do not ‘fatigue’ easily. They are found only in the heart.

Think

What is the secret behind the continuous functioning of heart without any rest in between ?

Some examples of muscular movements in our body :

1. Locomotor : Eg. walking.
2. Respiratory : Eg. movements of diaphragm
3. Speaking : Eg. muscles of vocal cord
4. Expression of emotions Eg. facial muscles.
5. Propulsion of food in the alimentary canal Eg. smooth muscles.
6. Pumping of blood Eg. cardiac muscle.
7. Urination Eg. contraction of smooth muscles of the Urinary bladder.

Activity 6.2

Find out other examples. Differentiate them into voluntary and involuntary

Connective tissues

The tissues which connect various other tissues of the body and provide support are called **connective tissues**.

Connective tissues basically consist of cells and fibres enclosed in a ground substance. Matrix may be soft or hard or liquid. Here, the cells are loosely arranged, hence have large amount of intercellular space. Connective tissue is richly supplied with blood. It is also known as **binding tissue** since it connects or binds other tissues.

Connective tissues are the most abundant and widely distributed in the body of complex animals.

Connective tissues are classified into three types on the basis of nature of matrix.

- Loose connective tissue
- Dense connective tissue
- Fluid connective tissue

Loose connective tissue

The tissue in which the fibres in the matrix are loosely arranged is called loose connective tissue. The areolar tissue, adipose tissue and reticular tissue are included under this group.

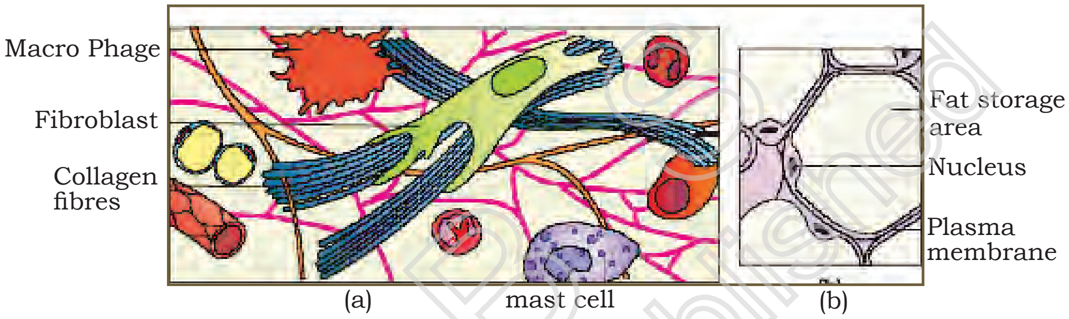


Fig. 6.11 Loose connective tissues
a. areolar tissue b. adipose tissue

Areolar tissue

Areolar tissue is found in many locations around the body. It is found in both dermis and sub-cutaneous layers of the skin. It binds the outer layers of the skin to the muscles beneath. Areolar tissue is also found in or around mucous membranes and around blood vessels and nerves.

There are three types of fibres

- White fibres or collagen fibres found in groups.
- Yellow fibres or elastic fibres found singly.
- Reticular fibres, forming a network.

Cells : The different types of cells are **fibroblasts, plasma cells, macrophages, adipose cells and mast cells**.

- **Fibroblasts** : They are large, flat, highly branched. They secrete and maintain fibres.
- **Plasma cells** : They are oval in shape and have a small nucleus. They produce antibodies.
- **Macrophages** : They are amoeboid in shape and are the wandering cells. They defend against micro-organisms, they ingest the micro-organisms and hence are called **phagocytes.**

- **Mast cells** : They are large cells. They have a spherical nucleus with granular cytoplasm. They are associated with secretion of substances like Serotonin, heparin and histamine.

Know this

Air spaces are found in between the fibres. Hence, it is called ***Areolar tissue.***

Adipose tissue : This tissue consists of closely packed fat cells. The cells are surrounded by fine reticular fibres. The tissue stores nutrients which are used as and when the body requires. It also provides insulation against cold and protects the body, like a shock absorber.

Reticular tissue : Reticular tissue provides frame work for important organs such as liver, spleen, bone marrow, tonsils and mucous membrane lining the respiratory tract and alimentary canal. It consists of reticular fibres.

Tendons and ligaments : Tendons contain more of white fibres. Tendons attach the muscles to the bones or cartilage. Ligaments consist of more of elastic fibres. They connect one bone to another. They help in the movement of bones.

Dense connective tissue : Connective tissue consisting of hard matrix is called **dense connective tissue.** The cells are embedded in a dense matrix which is composed of calcium carbonate and calcium phosphate.

Know this

Dense connective tissue forms the skeletal system, of the body providing an internal supporting frame work, in all vertebrates.

Skeletal system encloses the internal organs. The skull protects the brain, ears, eyes, nose and other organs in the face. The ribcage protects heart and lungs. The vertebral column protects the spinal cord. The organs of digestion, excretion, reproduction and many other organs in the abdomen are protected by the pelvic girdle and limbs are provided with support.

Dense connective tissue includes two types: cartilage and Bone

Cartilage

Cartilage Shows the following features.

Presence of transluscent or glassy matrix composed of chondrin. The matrix has cells called **chondrocytes** in spaces called **lacunae**. Cells may be present singly or in groups of two to three. Chondrocytes secrete the matrix.

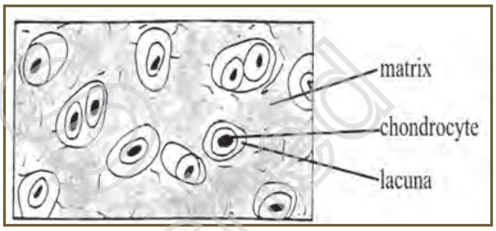


Fig. 6.12 Hyaline cartilage

Matrix also shows the presence of both white and yellow fibres. These fibres are not easily visible in cartilage because of the same refractive index of matrix and fibres.

Cartilage is externally surrounded by a connective tissue layer called **perichondrium**. It is vascular and provides nutrients and oxygen to chondrocytes. It is also a source of new cartilage cells.

Cartilage forms 'C' shaped rings in the trachea, bronchi.

Cartilage present in larynx, epiglottis, wall of the eustachian tube and pinna contains elastic fibres in the matrix. It is called **elastic cartilage**.

Cartilages found in between the vertebrae in the vertebral column chiefly contains collagen fibres. They are called **fibrous cartilages**. They bring about bending and stretching movements.

Bone tissue

Bone tissue is the most abundant skeletal material found in the body. A large part of the body weight is due to bone tissue.

Bone tissue consists of cells embedded in a firm calcified matrix. The matrix chiefly consists of collagen fibres, proteins and inorganic salts like calcium phosphate, chlorides of potassium, sodium and magnesium. The structure of the bone is designed to withstand stress and strain.

The long and strong bones of the limbs are filled with a fluid called **bone marrow**. Which consists of fat and blood vessels. It produces blood cells.

A section of bone reveals the following details.

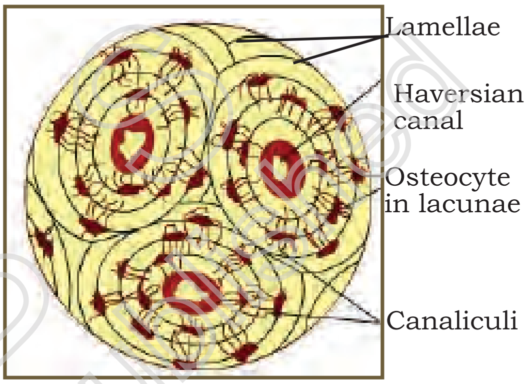


Fig. 6.13
Haversian systems

The structural unit of bone tissue is called **Haversian system**. It consists of a central haversian canal containing blood vessels and nerves.

It is surrounded by a matrix called **ossein**. Ossein contains collagen fibres and mineral salts chiefly of calcium phosphates. Ossein is arranged in the form of concentric layers called **lamellae**. Between the lamellae are fluid filled spaces called **lacunae**. Each lacuna has an osteocyte or bone cell. The lacunae belonging to the same lamella and adjoining lamellae are interconnected by fine canals called **canaliculi**. The osteocytes are interconnected by protoplasmic strands extending through the canaliculi. This shows that bone has a direct supply of blood unlike cartilage. The haversian canals of adjoining haversian systems are connected by transverse canals called **volkmamn's canal**.

Know this

- Smallest bone in our body is in the middle ear.
- Bone is a complex of various substances, 70 % salts and 30 % organic substance. In the inorganic component, 85 % is calcium phosphate.

Fluid connective tissue

In your previous classes you have learnt about the composition and functions of blood. Do you know that blood is also a connective tissue? Now, let us study blood as a connective tissue.

Blood and lymph are the fluid connective tissues of the body. They have a liquid matrix.

Blood

It is also called **vascular tissue**. The matrix is called **plasma**.

Blood cells like Red Blood Cells, white blood Cells and platelets are found floating in plasma. The liquid nature of the plasma facilitates easy transport of the various substances from one part of the body to another.

The red blood cells are involved in supplying oxygen to every cell in the body. They also remove carbon dioxide from the cells and transport it to the lungs. The number of RBC varies from 4.5 to 5.5 million cells / cubic mm of blood. RBCs are circular, biconcave discs having a life span of 100 to 120 days. They originate from bone marrow. RBCs enclose an iron containing pigment called haemoglobin. It helps in the transport of oxygen.

WBC’s are colourless cells, large, nucleated and less in number. Their number varies from 6000 to 10,000 cells /cubic mm of blood. They are amoeboid in shape. They are of two types depending on the presence of certain granules found in their cytoplasm namely **granular leucocytes** and **agranular leucocytes**.

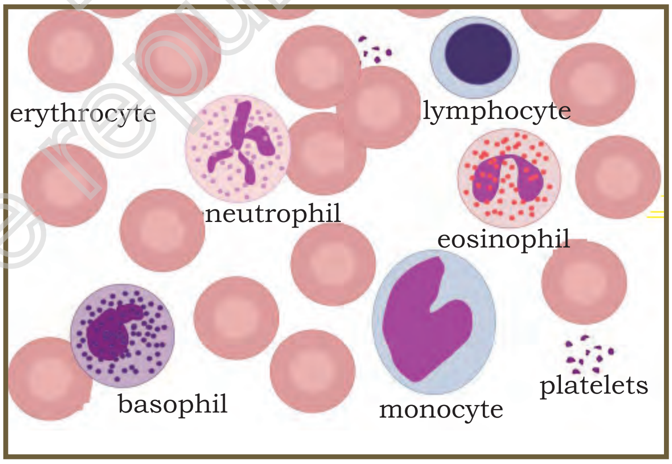


Fig. 6.14 Types of blood cells

Granular leucocytes have a granulated cytoplasm and lobed nucleus. They are classified into three types namely eosinophils, basophils and neutrophils.

Agranular leucocytes have a clear cytoplasm and unlobed nucleus. they are classified into two types namely lymphocytes and monocytes.

Platelets

These are found in the form of fragments of larger cells. These are about 2,50,000 platelets in 1 mm^3 of blood. They help in clotting of blood.

Activities 6.3

Richer the haemoglobin, stronger will be the energy level. How do you correlate?

Lymph

Lymph is a colourless fluid similar to blood in structure. It differs from blood only in the absence of RBC and some plasma proteins. Lymph flows in another set of capillaries known as **lymphatic capillaries**. These capillaries form lymph glands or lymph nodes. The lymphatic vessels empty lymph into the circulatory system.

Lymph produces antibodies which form an essential part of immune system of the body. It contains a type of white blood cells or phagocytes which remove bacteria and foreign bodies from the tissues.

Nerve tissue

You know that irritability is one of the basic characteristics of living organisms. This property is very well developed in nervees tissues. The nerve tissue responds to external and internal stimuli of the body. It transmits information in the form of nerve impulses from different parts of the body to the nerve centres. It also very quickly brings back the responses.

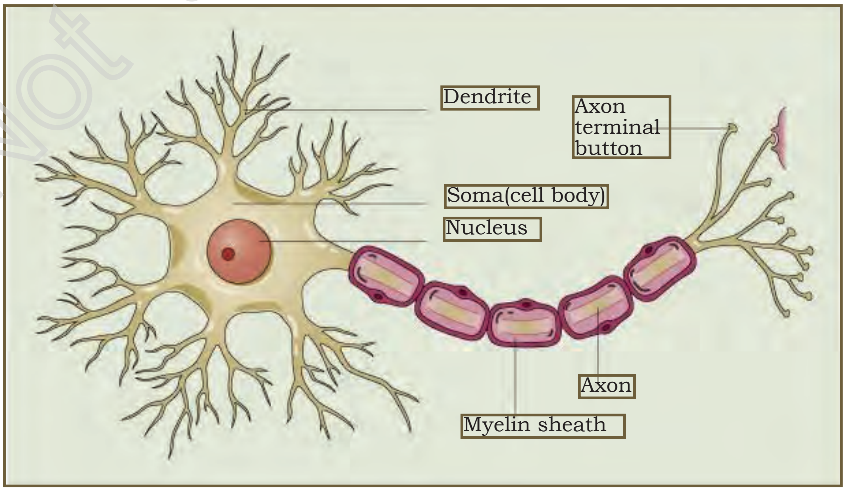


Fig. 6.15 A Neuron

The structural and functional unit of nerve tissue is the nerve cell or "Neuron". Observe the figure(6.16). The part consisting of a prominent nucleus is the cell body or cyton The short projections arising from the cell body are called **dendrites**, the long extension of the cell body is the 'axon'. The axon ends in a bunch of branches, called **telodendrons**. The axon is covered by a fatty sheath, called **myelin sheath**.

Know this

The fastest nerve impulses in humans travel at eight metres per second?

Activities 6.4

- Observe the pictures of different skeletons of vertebrate and find out how the skeletal system supports the organism in maintaining shape.
- Prepare coloured charts of different tissues and prepare the models of tissues under the guidance of your subject teacher.

Exercise

I. Choose the most appropriate answer and fill in the blanks.

1. When parenchyma has cells containing chloroplasts, it is called __________.

   a. aerenchyma　　b. chlorenchyma

   c. collenchyma　　d. sclerenchyma

2. The conducting elements in phloem are called __________.

   a. sieve tubes　　b. fibres

   c. Tracheae　　d. tracheids

3. Xylem tissue conducts __________.

   a. only water　　b. only food

   c. both water and food　　d. both water and minerals

4. The name endothelium refers to _________.

   a. columnar epithelium   b. ciliated epithelium

   c. cuboidal epithelium   d. squamous epithelium

5. In animals, fat is stored in __________.

   a. areolar tissue   b. cartilage tissue

   c. adipose tissue   d. reticular tissue

6. The structural and functional unit of nerve tissue is _________.

   a. neuron   b. axon

   c. dendrite   d. myelin

II. Give analogy for the following pairs

1. Heart : Involuntary muscle : : Limbs : _________.
2. Adipose tissue : body temperature : : Areolar tissue : _________.
3. Xylem : Water conducting : : Phloem : __________.
4. Calcium : Bone : : _________ : Blood.

III. Answer the following questions in two or three sentences.

1. What is a tissue?
2. What are the functions of epithelial tissue?
3. Name the water conducting elements in xylem.
4. What is the economic importance of Phloem tissue?
5. Why are xylem and phloem called vascular bundles?
6. What are the function of areolar tissue?
7. How does lymph protect the body?
8. What are the unique features of cardiac muscle?

CHAPTER 7

MICROBIAL DISEASES

After studying this chapter you

- know about the diseases caused by microbes.
- analyse the causes, symptoms and preventive measures for chickungunya, birdflu and dengue.
- understand the meaning and types of sexually transmitted infections
- analyse the causes symptoms and preventive measures in respect of syphilis, gonorrhea, genital herpes, genital warts, hepatitis -B and AIDS.

You have heard about certain diseases like Bird Flu, Chikungunya, AIDS. What may be the causes? How to prevent them? Let us try to get answers for such questions.

In your previous classes, you have studied about microbes, their types, their beneficiary effects as food in environmental management in fixing nitrogen etc. You also know about certain microbial infections and their preventive measures. Some of these diseases are caused by bacteria and some infections are due to viruses. In this chapter, let us learn about the common microbial diseases caused by bacteria and virus.

Chikungunya

The word **Chikungunya** is derived from **Makonde** language meaning 'that which bends up' as the person suffering from this condition complains of pain in joints for a long time.

This is an infection due to Alphavirus, also known as **CHIK-V**, transmitted to humans, by mosquitoes belonging to the species *Aedes aegyptii.*

Think

You know that many diseases are spread through mosquitoes.
What are the advantages of avoiding mosquito bites?

Know this

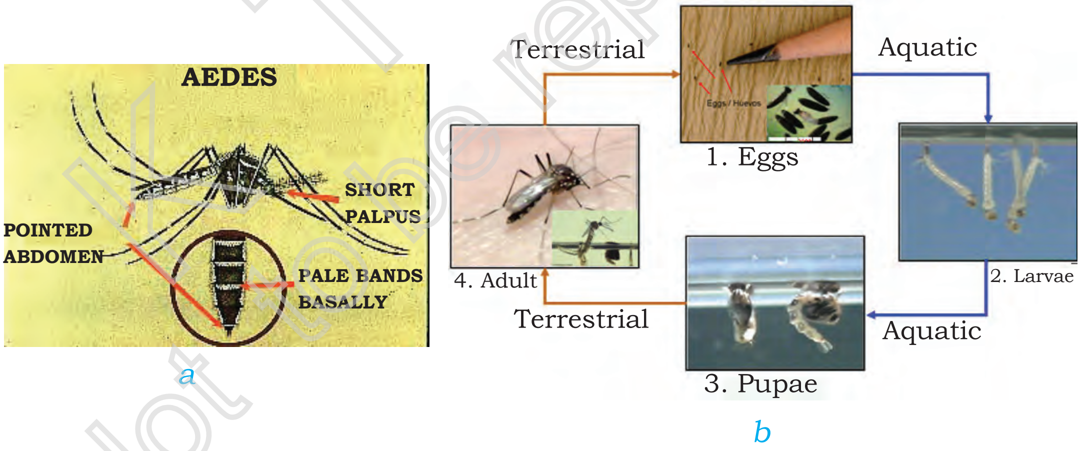
Mosquitoes do not bite. They pierce the skin and suck. However, in all languages it is said that masquitoes bite.

Symptoms

Symptoms include a fever up to 40^0 C (104^0 F) followed by rashes on the trunk region and occasionally on the limbs. It is accompanied by severe pain in multiple joints known as arthralgia or arthritis. This is also followed by headache, conjunctivitis and slight photophobia. Fever may last for two to five days. The joint pain may last for much longer period, some times for years depending upon the age.

How does Chikungunya spread?

The mosquitoes (*Aedes aegiptii*), breed in stagnant water. They typically bite during the day. They are known to be most active early in the morning and the late afternoon.



a

b

Fig. 7.1 Aedes aegipti : a. Structure b. Life cycle

Think

Why do chikungunya cases increase during monsoon season?

Methods to prevent the Disease

1. Keeping mosquitoes away is the basic thing to do. It is done by avoiding stagnation during monsoon season.
2. Water collection in coconut shells, waste containers like unused pots should be cleared now and then.

3. Insecticides sprayed during the season may also control the disease by killing immature larvae of mosquitoes.
4. Wearing long sleeved and full length garment to avoid exposure.
5. Using safe mosquito repellents and mosquito nets to prevent mosquito bite.

Dengue

Dengue fever also known as **break – bone fever**. It is an infectious tropical disease caused by the **Dengue virus.**

It is also transmitted by the same mosquito *Aedes aegyptii*. This is a life – threatening fever, resulting in bleeding, low levels of blood platelets and blood plasma leakage, with low blood pressure.

Symptoms

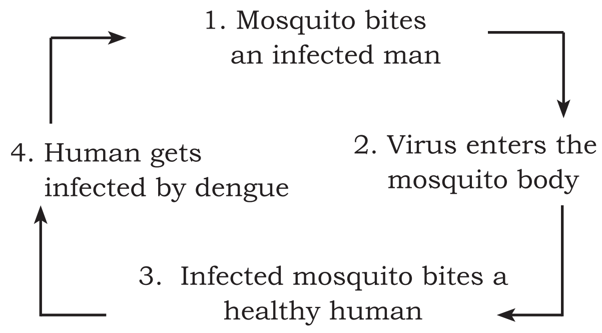
It is an acute illness of sudden onset beginning with headache, fever, exhaustion, severe muscle and joint pain, swollen glands, and rashes. Other signs include bleeding gums, severe pain behind the eyes, and redness in palms and soles.

Dengue can affect anyone. It tends to be more severe in people with weak immune system.

The main Symptom of dengue is the 'reduced platelet count' of less than one lakh / cubic mm of blood. When the blood composition is diluted, it may become fatal.

How does dengue infect humans?

Already you are aware that the mosquitoes spread Malaria and Chikungunya. The same vector causes Dengue.


1. Mosquito bites an infected man
2. Virus enters the mosquito body
3. Infected mosquito bites a healthy human
4. Human gets infected by dengue

Scheme showing mode of transmission of dangue

Activity 7.1

How to identify Aedes aegyptii?

Observe the mosquitoes that are active during day time and are biting during day. Catch them in an insect catcher or a net and observe the legs. It is easily recognized by white spots on the body and the leg region. The mosquito rests indoors in dark places. When it is outside, it rests in cool and shaded places.

You have experienced mosquito bites during late evenings and in the night. The bites are very sharp and cause pain. When Aedes aegyptii bites during day time, it is likely to go unnoticed as it does not cause skin irritation. Hence, easily a person becomes susceptible to infection.

Know this

An extraction of tender leaves of papaya is given to Dengue patients. It works like a miracle in noticebly increasing the number of platelets.

Bird Flu or Avian Flu

Bird Flu or Avian influenza is the Flu infection in birds. The virus that causes the bird infection can change or mutate to infect humans.

Hundreds of people have become infected with this virus. 60 % of those infected normally die.

How does it spread?

The avian flu virus is known to survive in the environment for long period of time. Infection may spread simply by touching contaminated surfaces. Birds infected with this flu can continue to release the virus in their faeces and saliva for as long as 10 days.

Symptoms

The symptoms of Avian Flu depends on the strain of virus. Infection in humans causes symptoms like – cough, diarrhoea, breathing difficulty, fever more than 38^0 C, headache, muscle pain, running nose and sore throat.

Prevention

- Travellers should avoid visits to bird markets of infected areas.
- People who work with birds should use protective clothing and special breathing masks.
- Partially cooked and uncooked meat should be avoided.

Syphilis

Syphilis is a sexually transmitted disease (STD), caused by the bacterium – *Treponema pallidum*.

The disease is transmitted through sexual contact, from mother to foetus through placenta or direct contact with infected blood.

Ulcers appear on the nose, palate and lower leg. There will be damage to organs, like the brain, nerves, eyes, heart, blood vessels, liver, bones, and joints. There will be difficulty in coordinating muscular movements, paralysis, numbness, gradual blindness, and dementia (memory loss).

The damage may be serious enough to cause death.

Prevention

The surest way to avoid transmission of this disease, is to abstain from sexual contact.

Gonorrhea

Gonorrhea is a common sexually transmitted infection caused by the bacterium *Neisseria gonorrhoeae*. The usual symptoms in men are burning sensation with urination and discharge from genitals. Women, show vaginal discharge and pelvic pain.

Prevention

The only sure way of preventing gonorrhea is abstaining from sexual intercourse. The risk of infection is reduced by using condoms.

Genital Warts

They are soft growths on the skin and mucus membranes of the genitals caused by sexual contacts.

Causes

The genital warts are caused by a virus called **Human Papilloma virus** (HPV). There are more than 70 different types of HPV. Certain types of HPV can lead to cervical cancer or anal cancer.

Prevention

- Avoiding any kind of sexual contact is the safest way.
- There are vaccines for females between 9 – 26 years to protect against HPV type.

Genital Herpes

Genital Herpes is a sexually transmitted disease (STD) caused by the **Herpes Simplex Viruses type I** (HSV – I) and type 2 (HSV – 2). The infection signs are the appearance of one or more blisters on or around the genitals or rectum. The blisters break leaving tender ulcers or sores and may take two to four weeks to heal. Later another outbreak can appear weeks or months after the first.

Prevention

For any STD and STI, the safest way is to avoid sexual contact.

Hepatitis B

You might have heard about liver infection or cirrhosis. It is related to Hepatitis B. Hepatitis B is caused by infection of hepatitis B virus (HBV). It gets highly concentrated in blood. Other body fluids like saliva, wound exudates, semen and vaginal secretions, contain less amount of this virus.

HBV is more infectious and relatively more stable in the environment than other blood borne pathogens like HCV and HIV.

It is transmitted by exposure to infected blood or body fluids. It is also transmitted through sexual contact and drug abuse.

Prevention

A vaccine called hepatitis B immune Globulin (HBIG) provides temporary protection for 3 – 6 months from HBV infection.

Know this

World wide, an estimated two billion people have been infected with the hepatitis B virus.

AIDS - Acquired Immuno Deficiency Syndrome

AIDS was recognised for the first time in USA in 1981. It is caused by the infection of a virus called human immuno deficiency virus (HIV). In India the first AIDS patient was identified at Chennai in 1987.

Structure of HIV

HIV is spherical in shape containing RNA as its genetic material. It is covered by a membrane made up of two layers of fatty material. Inside the membrane, a core made up of proteins is found. In the centre of the core, the viral RNA is present along with enzyme reverse transcriptase. This enzyme acts as a catalyst on RNA helping in the synthesis of DNA in the host cell. Hence, HIV is classified as a retrovirus.

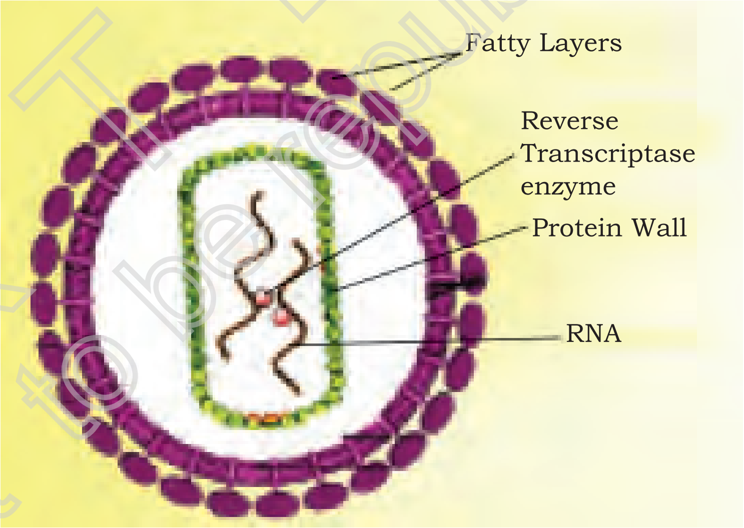


Fig. 7.2 Structure of HIV

As and when a new DNA is formed by these viruses in the host cells, HIV gets adapted to the host body so well that the body cells fail to identify this virus as intruder. Thus, the symptoms may take years to appear. Ultimately, HIV destroys the natural immunity of the body. This leads to secondary infections. Thus, the affected person is attacked by various contagious diseases, finally leading to death.

HIV infected person is described as HIV +ve. It is to be remembered here, that symptoms of AIDS does not appear in all HIV+ve persons.

Spread of HIV

HIV is not spread through everyday school and social activities. It is not spread through casual contact with persons, neither through air nor water. It is also not spread just by being around with an infected person.

However, modes of transmission are only as follows.

- Sexual contact with an infected person.
- Transfusion of infected blood.
- Sharing of needles and syringes with an infected person.
- From an infected mother to the embryo through placenta.

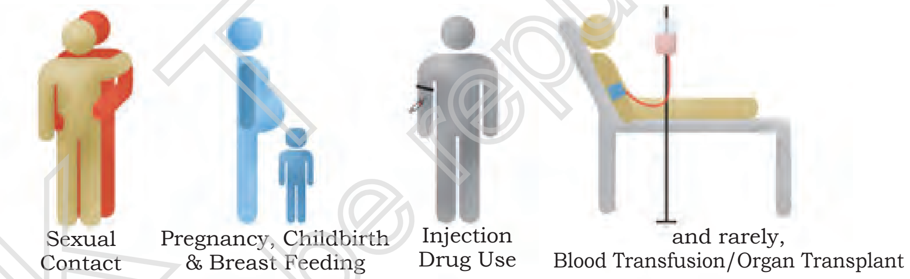


Fig 7.3 Modes of HIV transmission

Know this

Why mosquitoes do not spread AIDS?

Probably, the most commonly asked question about AIDS is whether the virus spreads through mosquitoes or other blood – sucking insects. Fortunately the answer is No.

Malarial parasites require certain species of mosquitoes to complete their life cycle. The parasites are sucked into the mosquito's body through the blood meal from an infected person. They develop and multiply in gut cells of the host and migrate to the salivary glands. When an infected mosquito bites a person, the parasites get into his blood stream. HIV multiplies only in lymphocytes and infection is acquired through contact with body fluids like semen, blood, vaginal fluids.

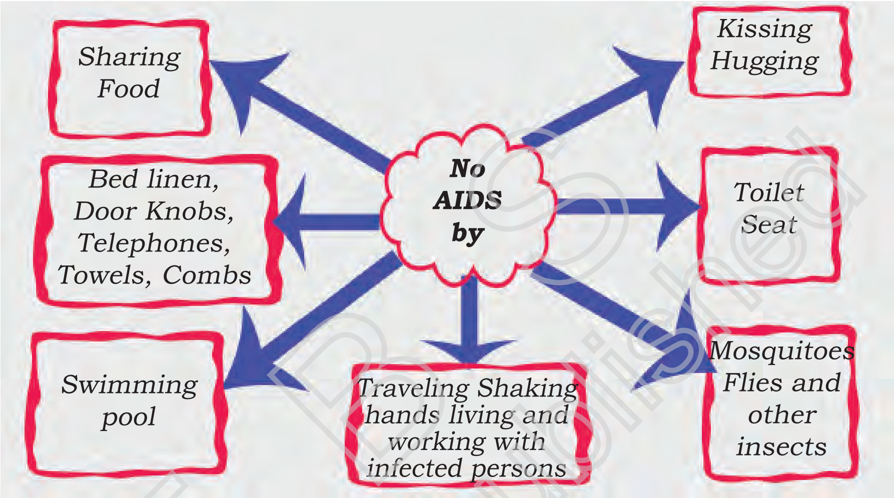

No AIDS by
Sharing Food
Kissing Hugging
Bed linen, Door Knobs, Telephones, Towels, Combs
Toilet Seat
Swimming pool
Traveling Shaking hands living and working with infected persons
Mosquitoes Flies and other insects

Fig. 7.4 Ways by which AIDS can not spread

Prevention

There is no medicine for AIDS. The only way is to avoid HIV infection.

The safest way to protect oneself from HIV infection is by consistently practising the **3A**'s of HIV prevention :

- **A**voiding sex with multiple partners.
- **A**bstaining from drug use or use of other skin piercing instruments unless absolutely necessary (i.e. medical emergency)
- **A**voiding contact with body fluids.

Know this

- *Know about AIDS to say No to AIDS*
- *Beware of AIDS, be aware of AIDS*

Exercise

I. Fill in the blanks with suitable words.

1. Joint pain is one of the symptoms of the viral disease ___________
2. The most characteristic symptom of dengue is a fall in the ______________ .
3. Syphilis is a kind of _____________ .
4. Gonorrhea is caused by the infection of _______________.
5. The virus responsible for causing genital warts, is called _________________ .
6. The viral infection in the liver represents a disease called ________________.

II. Answer the following questions.

1. Make a list of the common symptoms of Chikungunya.
2. Name the mosquito responsible for spreading both Chikungunya and Dengue.
3. What are the symptoms of Dengue?
4. What is meant by sexually transmitted diseases? Name any two of them.
5. Name the vaccine given to prevent hepatitis.
6. Name the viruses responsible for-Chikungunya, genital warts, hepatitis and AIDS.
7. Describe the structure of HIV.
8. What are the ways by which HIV infection spread?

CHAPTER 8

TYPES OF MOTION

After studying this chapter you

- identify linear motion and circular motion.
- give examples for wave motion.
- recall the fact that waves carry energy but there is no transfer of matter.
- differentiate between a mechanical wave and an electromagnetic wave.
- solve numerical problems on wave motion of the wave.
- identify simple harmonic motion in day to day life.
- explain simple harmonic motion with examples.

Everything around us is moving in one way or the other. In fact stones, trees, roadways which seem to be stationary also move with the earth's rotation. Motion is a natural event that involves a change in the position / location of an object with time.

Study of motion of objects is a very important aspect of physics. Chemical reactions are possible only because of movement and collision. Geologists use physics of waves to study and measure the tectonic-plate motion and predict earthquake. Cosmologists consider movents to study the behavior of heavenly bodies and doctors use it to map the flow of blood to check whether the arteries are blocked.

Imperceptible Motions

- Constituents of solids are in a state of continuous vibration, not visible to the naked eye.
- The revolution and spin of the earth is imperceptible inspite of their high speed.
- Theory of plate tectonics tells us that the continents are drifting at the slow speed.

Know this

Both Kanaada and Democritus proposed that matter consists of atom and void. Why did they imagine the presence of void?-without accepting void, we cannot imagine movement!

Activity 8.1

Take some water in a trough and float a piece of cork in it. By dipping your finger, disturb the water and observe the floating body.

Why did the cork move up and down, but not forward?

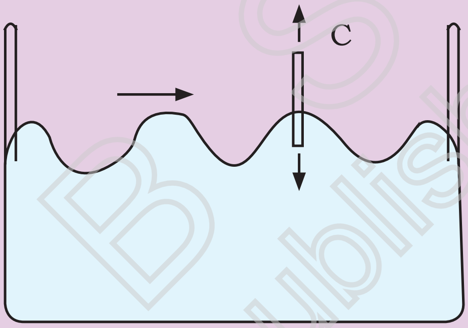


Fig 8.1 Water waves

Think

In wave motion, energy is transmitted from one place to another. Can the wave energy be transformed into any other form?

Early contributions to the wave theory

Scientific theories of wave propagation became more prominent in the 17th century A.D when Galileo Galilee (1564-1642) published a clear statement of connection between vibrating bodies and the sounds they produce.

The wave is a wonder. Even though wave travels through medium and vacuum, that which gets transferred in energy only.

Facts About Wave Motion

- A wave is produced by the periodic disturbance at a point in a medium.
- When a wave propagates in a medium, the particles of the medium vibrate about their mean position and the energy is transferred without the transfer of the particles of the medium.
- Velocity of the disturbance transmitted in a medium is called wave velocity.
- The velocity of the wave depends on the nature of the medium not the energy content.

- If the periodic disturbance in a medium (wave) moves through a distance ' λ', and if there are 'n' such cycles per second, the wave velocity v=nλ.

  So, wave velocity, wavelength and the frequency are related by the equation; v=nλ.

- Time period (T) and the frequency(n) of the wave are related by the equation. $T = \frac{1}{n}$

Know this

In the electromagnetic waves, the wave velocity is represented by "c" c-velocity of light in vacuum. c=3x10^8 m s^{-1}

Very large distances which could not be measured was called celeris. The first letter of this word "c" is used as the symbol for the speed of light in vacuum.

The waves which need a material medium for their propagation are called **Mechanical waves**. We come across these waves very often. Examples of these waves include water waves and seismic waves.

They can travel only in a material medium such as water, air and earth.

Imagine

If light required a medium, we would not have received solar energy.

Comparison of transverse waves and longitudinal waves

Transverse Waves	Longitudinal Waves
• Particles vibrate in the direction perpendicular to the direction of wave propagation.	• Particles vibrate along the direction of the propagation.
• The wave propagates in the form of crests and troughs.	• The wave propagates in the form of compressions and rarefactions.
• Alternate crests and troughs constitute a wave. Eg. Light waves, waves on surface of water, waves on a string.	• Alternate compressions and rarefactions constitute a wave. Eg: Sound waves, vibrations in gases, oscillations of spring.

The waves associated with electric and magnetic fields, resulting from the acceleration of an electric charge are called **Electromagnetic waves**. These waves include visible and ultraviolet light, radio waves, X-rays etc. These waves require no material medium for their propagation.

Activity 8.2

Tie a rope to a hook. Hold the other end of it and move this end up and down. A wave starts from the point where you are holding the thread and appear to move to the other end. Identify the wave produced.

Did you know this?

Tsunamis are mistaken as tidal waves of unusual speed. But these are the waves caused by earthquake, landslide or volcanic eruption under the ocean. These unusual waves have a speed of about hundreds of kilo metres per hour.

Let us solve some numerical problems on wave motion Numericals

1. **A 50 Hz vibrator produces air waves that speed out at 340 ms^{-1}. What is** a) Their time period? b) Their wave length?

Solution

$n = 50$ Hz $v = 340$ m/s

(i) $T = \frac{1}{n} = \frac{1}{50} = 0.02$ s

The time period of the air wave is 0.02 s.

(ii) $v = n\lambda$

$\lambda = \frac{v}{n} = \frac{340}{50} = 6.8$ m

The wave length is 6.8 m

2. **The wavelength of a longitudinal wave is 1 cm, and its velocity in air is 330 ms^{-1}. Find out the frequency of this wave.**

Solution

$\lambda = 1\,\text{cm} = 0.01\,\text{m}$

$v = 330\,\text{ms}^{-1}$

$v = n\lambda$

$n = \frac{v}{\lambda} = \frac{330}{0.01} = 33000\,\text{Hz} = 33 \times 10^{3}\,\text{Hz}$

The frequency of the wave is 33x10^3 Hz.

3. **The frequency of a sound wave is 256 Hz and its wavelength is 1.2 m. Calculate its wave velocity.**

Solution

$n = 256\ \text{Hz}$

$\lambda = 1.2\ \text{m}$

$v = n\lambda$

$v = 256 \times 1.2 = 307.2\ \text{ms}^{-1}$

The velocity of the sound wave is 307.2 ms^{-1}.

Simple harmonic motion

Activity 8.3

Take the bob of the simple pendulum to the side indicated by the arrow in the figure 8.2 and allow it to move freely. The bob after reaching the equilibrium position moves further. After reaching its extreme position it moves back to the equilibrium position.

This to and fro motion repeats. One to and fro motion is called one cycle. This type of motion is called oscillation.

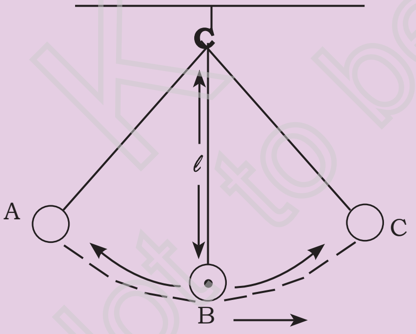


Fig 8.2 Oscillating pendulum

A,and C-exrtreme positions

B-equilibrium position

Time period of simple pendulum is given by

$$T = 2\Pi\sqrt{\frac{\ell}{g}}$$

$\ell \rightarrow$ effective length of the pendulum

$g \rightarrow$ gravitational acceleration($g = 9.8\text{m s}^{-1}$)

When the bob is in its extreme position, it is momentarily paused. It changes its direction and starts moving towards the equilibrium position with acceleration.

At either position of maximum displacement of the bob, the potential energy is greatest. Instantly, very next moment, velocity and acceleration takes place in the opposite direction.

We can predict the position of the bob by studying this motion which repeats after regular interval of time. Such a motion is called Simple Harmonic Motion.

This is the wonder of simple harmonic motion. On its own, the direction and the acceleration varies leading to movement in the opposite direction.

Think

In the simple pendulum, the bob changes its direction of motion twice in a cycle. Even though if we have not applied any external force. How does this happen?

Know this

Galileo enunciated the laws of pendulum using the pulse of his hand (instead of watch) and studied the oscillating lamp in the Church!

Fig. 8.3
Galileo

Characteristic Properties Of Simple Harmonic Motion

The characteristic properties like, amplitude, oscillation and time period of wave also holds good for simple harmonic motion.

The maximum displacement of the particle on either side of the equilibrium position is called **Amplitude**. One complete to and fro motion of the particle about its mean position is called **Oscillation**. Time taken by the body to complete one oscillation is called **Time period**.

Examples of simple harmonic motion

1. Oscillation of simple pendulum.
2. When a tuning fork is hit against rubber pad, its prongs execute simple harmonic motion.
3. When the load attached to the lower end of a spring suspended from a support is pulled and released, it executes simple harmonic motion.
4. When the bus is in the clutch gear, we can see a vibration and hear the sound produced by it. This is simple harmonic motion.

Applications of simple harmonic motion

1. Simple harmonic motion of a pendulum is used for the measurement of time.
2. Tuning of the musical instrument is done with the vibrating tuning fork which executes simple harmonic motion.
3. Wave is a consequence of simple harmonic motion. Study of waves is indirectly the study of simple harmonic motion.
4. Molecules are in simple harmonic motion. This study is called vibration spectroscopy.

Exercise

I. Four alternatives are given to each of the incomplete statements/questions. Choose the correct answer

1. Which of the following represent circular motion ____________

   a) ball sliding down an inclined plane.

   b) motion of a simple pendulum.

   c) A freely falling body.

   d) A stone tied to a thread and whirled.

2. The wave carries______________

   a) power b) energy c) displacement d) work

3. Which of the following is a Longitudinal wave?______________

   a) radio wave b) X-rays c) light waves d) sound waves.

4. The S.I unit of wavelength is________________

   a) cm b) dm c) m d) km

5. The wavelength of a wave is 4 m and two waves per second passes through a point, then the speed of the wave is______________

   a) 2 m s^{-1} b) 8 m s^{-1} c) 6 m s^{-1} d) 4 m s^{-1}

II. Complete the following statements

1. Waves are produced by ______________ .
2. The speed of a wave depends on______________ .
3. The distance between two consecutive compressions / rarefaction is ______________.
4. The type of wave to which Electromagnetic wave belongs to ________________ .
5. In a longitudinal wave, The vibration of particles, and the direction of wave are _______________ .

III. Match the following

A	B
1. Longitudinal wave	crests and troughs
2. Transverse wave	oscillation of a simple pendulum
3. Simple harmonic motion	oscillations in spring
	motion along a circular path
	motion of an arrow released from a bow

IV. Answer the following questions

1. Give the differences between a transverse wave and a longitudinal wave.
2. Does the particles of the medium in which a wave moves travel along with the wave? Explain with an example.
3. If we double the frequency of a vibrating object, what happens to its time period?
4. If the frequency of a transverse wave is 10 Hz. And the distance between the two consecutive wave crests is 2 m. Calculate the wave speed.
5. Define simple harmonic motion and Give two examples of the same.
6. Give two practical applications of simple harmonic motion.

CHAPTER 9

HEAT ENGINES

After studying this chapter you

- define the meaning of heat engines.
- distinguish the principle between a steam engine and an internal combustion engine.
- draw the diagram of a steam engine.
- state the limitations of a steam engine.
- explain the working of a petrol engine.
- draw the diagram of a petrol engine.
- explain the functioning of a diesel engine.
- mention the applications of heat engines.
- calculate the efficiency of heat engines.

Earlier you have studied that heat is a form of energy. you have also studied that energy can be transformed from one form to another. For example electrical energy can be converted into heat, light and mechanical energies by using suitable devices.

Exercise 9.1

Make a list of the transformations of energy in the following devices.

i) photocells   ii) dynamo   iii) motor   iv) fan

How do we make use of heat energy?

We can use heat energy for cooking, for carrying out experiments in the laboratory. These examples are applications of effects of heat. The effects of heat can be summarised as,

i) increase in the temperature of a body.

ii) expansion of the body.

iii) change of state of matter.

iv) chemical change in the body

Increase in the temperature of a body does not lead us to the designing of a device which convert heat energy into mechanical energy. Expansion of solids, liquids and gases by heat will be at very low pace to make use of it in developing a heat engine. Change of liquid to gaseous state of matter is most significant in designing heat engines. If a small quantity of water is converted into steam, it occupies more volume by expansion and exerts pressure. Approximately the volume of steam will be around 1,500 times at STP than the volume of water from which it is obtained by heating. The pressure exerted by the large volume of steam is the basis of working of steam engine. Chemical change of liquid fuels like petrol and diesel when undergo combustion, produce large volume of gases and exert pressure. This is the basis of working of petrol engine or diesel engine.

Air current has two types of movement,

i) random movement of molecules within the system.

ii) enmass laminar flow along the direction of flow.

The second type of movement of molecules is applicable to the working of heat engines, as it results in developing pressure.

What is a heat engine? A heat engine is a device which converts heat energy into mechanical energy. There are two types of heat engines, i) steam engine ii) internal combustion engine.

Know this

The conversion of steam pressure into mechanical movement was known in Roman Egypt in the first century. Heron of Alexandria prepared one such working model. The following diagrams illustrate the early form of a heat engine. Can you prepare such a model?

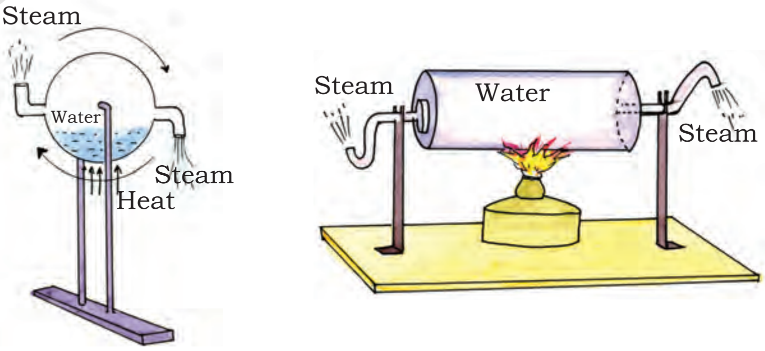


Figure No 9.1(a)

Figure No 9.1(b)

Steam engines of the first century

Think

A hollow rubber ball kept at rest on a table does not show any movement. The kinetic energy of the random motion of all the gaseous molecules present inside the ball cannot make the ball move even though the molecules inside the ball are at the order of several thousand metres per second. Can you give reason for this? Recall 'Balanced forces' that you have studied in eighth standard.

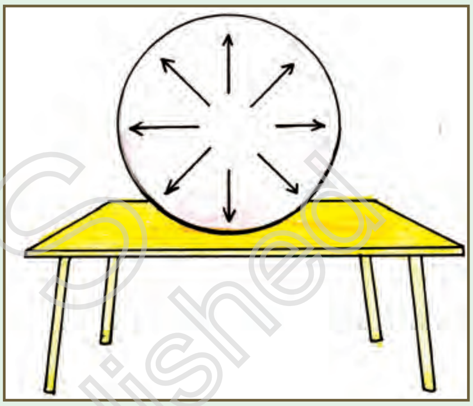


Fig. 9.2
Hollow rubber ball at rest

First commercially useful steam engine was constructed by Thomas Savery. James watt improved upon it by using cylinder and valve system. Steam locomotives helped to bring about industrial revolution.

Let us consider the working of a steam engine.

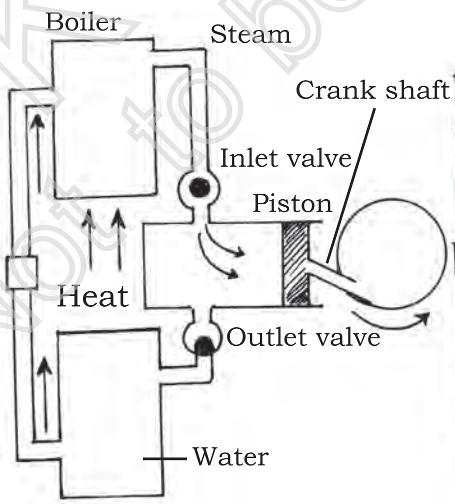


Fig. 9.3(a)
Expansion Stroke

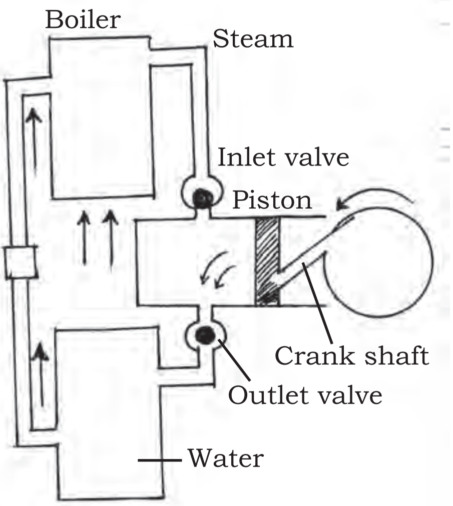


Fig. 9.3 (b)
Exhaust Stroke

Water is heated in a boiler, to generate steam of high pressure which is passed into a cylinder fitted with a piston. As steam occupies a much larger volume than the same amount of water, it exerts great pressure on the walls of the container in all directions. As the steam expands in the cylinder, it pushes the piston forward. Crankshaft connected to the piston also moves. Crank shaft converts linear movement of the piston into circular motion. The wheel of the crank shaft makes half rotation during the expansion stroke.

Activity 9.1

Observe a toy cycle. The legs of the puppet sitting on the cycle moves up and down where as the wheels of the cycle makes a circular motion. Observe the arrangement to know about crankshaft. The circular motion of wind mills is converted into linear movement by crankshaft to pump water from a well. Can you think of devices where circular motion is converted into linear motion and linear motion into circular motion?

Steam expands and it pushes the piston forward and loses some of its kinetic energy. As a result, it condenses into water. The piston is then pushed back into the cylinder due to low pressure region. Due to inertia of the crankshaft, the wheel makes another half rotation and completes one cycle. This is exhaust stroke. The condensed water is expelled out and fresh steam is let in to repeat the process. In steam engines, the fuel, mainly coal is burnt outside the engine.

Fig. 9.4 steam locomotive

In steam engines there are special shutters called **valves**. Valves open in one direction only to let in or to let out steam at appropriate stages. Steam engines were used to design cars in earlier days. They were also used to run trains. But the use of steam engines for transport vehicles is outdated today because of their low efficiency.

Know this

In thermal power plants and nuclear power plants, heat is not directly transformed into electricity. Heat energy of the burning coal and the controlled fission chain reaction, respectively is used to generate steam. The steam is used in heat engines to convert into mechanical energy. Mechanical energy is transformed into electrical energy using generators.

Limitations of Steam Engine

1. Construction of steam engine is not as simple as shown in the diagram. The fuel chamber is not shown in the diagram. The bulk and the heavy weight of the engine is not suitable for small vehicles. Can you imagine a scooter running on a steam engine?

2. The efficiency of the engine is very low. There is more loss of heat in this type of engine. Much of the heat is lost in the boiling of water, to increase the temperature of water to its boiling point.

3. Heating water, to produce steam, takes time and the engine cannot start instantly. To keep the steam ready, the fuel should be burnt continuously even if the engine is at rest. The limitations of steam engine lead to the discovery of internal combustion engine. Rudolf Diesel and Nikolaus were the two pioneers in this effort. Today internal combustion engines are used in all transport vehicles, Scooters, cars, buses, lorries and trains all work using internal combustion engines. Depending upon the fuel used, internal combustion engines are of two types. They are petrol engine and diesel engine.

Activity 9.2

Fix a cork to a hard glass bottle in a way that it is air tight. Introduce a gas lighter through a hole made in the body of the bottle. Take care to see that air does not enter through this hole. Open the cork and add five or six drops of spirit into the bottle. Replace the cork and mix spirit with air by shaking the bottle well. Fix the bottle firmly to a stand. Ignite the mixture by operating the gas lighter. Observe what happens ? The cork flies off. Why? The combustion of spirit produces heat and the products of combustion are gases which have greater volume than the fuel. The pressure exerted by the gases make the cork fly off. Heat energy gets converted into mechanical energy. Internal combustion engines work on this basis.

Petrol Engine

In a petrol engine there is an air tight piston that can be moved smoothly inside a cylinder. The cylinder is provided with two valves, inlet valve and outlet valve. There is a spark plug. The piston is linked with a crankshaft. The engine is linked with a carburettor. In the carburettor, petrol and air are mixed in proper proportions before letting into the engine.

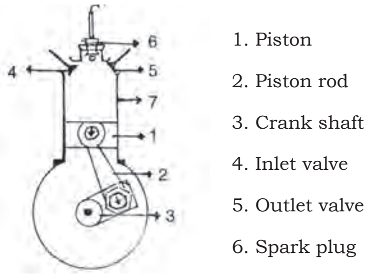


Fig. 9.5 parts of a petrol engine

Figure number 9.5 shows the main parts of a petrol engine.

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Let us consider the working of a petrol engine. There are five stages in its operation. Figure numbers 9.6 (a,b,c,d and e) indicate the stages.

A) Intake stroke : The vapourised mixture of petrol and air is let in through the inlet valve. The outlet valve remains closed. Piston moves away from the spark plug.

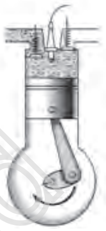


Fig. 9.6 a

B) Compression stroke : Both the valves are closed and the mixture of air and petrol is compressed by the piston moving towards the spark plug. Though the compression increases the temperature of the mixture, it is not sufficient to ignite the petrol.

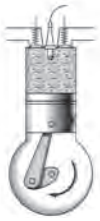


Fig. 9.6 b

C) Ignition stroke : The compressed air and petrol mixture is ignited by the sparks produced by the spark plug.

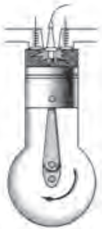


Fig. 9.6 c

D) Expansion stroke : The fuel burns quickly producing heat and gaseous products such as, carbon dioxide, carbon monoxide and water vapour are formed along with carbon particles. The gaseous products expand suddenly. Piston is pushed outwards with great force.

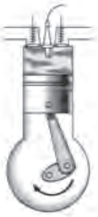


Fig. 9.6 d

E) Exhaust stroke : The outlet valve opens. Piston moves back. The products of combustion gases are pushed out of the cylinder through the exhaust valve.

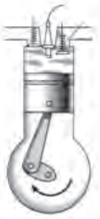


Fig. 9.6 e

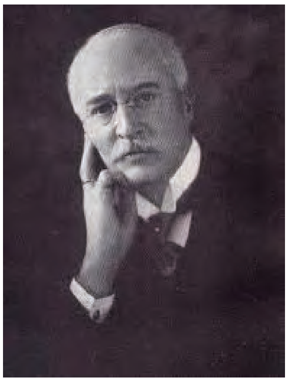
The above cycle is repeated. Piston moves to and fro quickly. Pushing the crankshaft and making the wheel rotate rapidly. The ignition stage and the expansion stage are together called power stroke. It is interesting to note that the initial kinetic energy needed to start the cycle is provided by starter motor or kick start.

Note : The motion of piston from one end to another end is usually called the stroke of the heat engine. Stroke may also refer to the stages of working of a heat engine.

Petrol engines are used in light weight vehicles like cars, scooters and motorcycles. The cost of the petrol is very high when compared to fuels like diesel oil. The continuous supply of petrol also results in the wastage of small quantity of petrol, as a part of petrol does not undergo combustion completely. On the other hand, diesel oil, has high ignition temperature and is not ignited by spark plug. Some modifications in the internal combustion engines are necessary if diesel, which is comparatively cheaper than petrol, is to be used in internal combustion engines.

Diesel Engine

The construction of a diesel engine is similar to that of a petrol engine except the spark plug. In the place of spark plug there will be compressor in which intake and compression leads to combustion.



Rudolf Christian Kart Diesel (18-3-1858 to 29-9-1913)

Rudolf Diesel was a German inventor and mechanical engineer. He is famous for the invention of Diesel engine. He designed many heat engines, including a solar powered air engine. In 1893 he published a paper describing an engine with combustion within a cylinder. His engine was the first that proved that fuel could be ignited without spark plug. He operated his first successful engine in 1897. He also experimented with vegetable oils as fuels in internal combustion engine. Usually scientific inventions and scientific laws are named after the scientist like Newton's Laws, Raman effect. But the name of Rudolf Diesel is given to hydrocarbon fuel. We call the fuel as diesel.

The compression ratio of air is to fuel in the diesel engine is 14 : 1 to 25 : 1, as compared to petrol engine ratio of 4 : 1 to 10 : 1. As a result of compression, high temperature of around 1000 K is produced inside the engine. A controlled quantity of diesel in the form of micelles is injected into the cylinder. The micelles burn on compression heat, leading to a presure impulse. The working of diesel engine also cosists of the five strokes of petrol engine. During intake stroke, filtered air alone is sent into the cylinder and compressed. The compression generates enough heat to ignite the fuel. At the end of compression stroke diesel in the form of micelles, is injected into the cylinder. Diesel bursts into flame instantaneously. The products of combustion are high pressure gases. Due to the expansion of gases the piston is pushed. Spent gases are ejected out of the cylinder during exhaust stroke.

THINK

Diesel engines are best suited for heavy vehicles, such as lorries, trucks, railway engines and ships. why ?

Diesel engines are not only used in transport vehicles, but also in generators to produce electricity. You might have observed the working of such generators near shops whenever there is no power supply. The sound of the engine and the smell of spent gases draw the attention of people towards such generators.

Some sugarcane juice vendors also use diesel engines to crush the sugar cane. Some cement concrete mixers work using diesel engines. You might have also seen the diesel engines at the sight of road constructions, where 'Tar' is mixed with 'crushed stones'. Can you think of any other uses of a diesel engine?

Activity 9.3

Visit a nearby automobile garage. Collect information about carburettor, air filter and spark plug.

Know this

Emission test : *In internal combustion engines the exhaust gases contain carbon dioxide, colloidal carbon particles, water vapour and carbon monoxide. Carbon monoxide is formed due to the incomplete combustion of the fuels. Carbon monoxide is a health hazard. More carbon monoxide is produced if the engine is not maintained properly.*

To control the pollution of air there is certain limit on the amount of carbon monoxide released by the vehicles. Periodically the vehicles have to undergo 'Emission Test' which is a test for carbon monoxide. The exhaust gases released by the vehicles should not cross the limit fixed, during the test.

Some cars and autorikshaws use LPG as fuel. LPG is also used in stoves. When it is used in stoves emission test is not necessary. Why?

Activity 9.4

From the internet find out the meanings of i) unleaded petrol ii) Antiknock value of petrol. iii) CNG as fuel. Visit a petrol bunk and find out the meaning of premium quality petrol.

Comparative study of petrol engine and diesel engine

Diesel Engine	**Petrol Engine**
1. Diesel engines are compression ignition engines. Spark plug is not required.	1. Petrol engines are spark ignition engines. Require spark plug.
2. Micells of diesel are used as fuel.	2. Petrol vapour is used as fuel.
3. The cost of diesel is comparatively less.	3. The cost of petrol is comparatively high.
4. Expansion against constant pressure.	4. Expansion of gaseous products with pressure impulse.
5. Efficiency is comparatively more.	5. Efficiency is comparatively less.
6. Pollution intensity is high	6. Pollution intensity is low

Efficiency of Heat Engine

Any engine can convert only a part of energy into mechanical energy. The efficiency of a heat engine is defined as the ratio of the actual work done to the heat energy consumed. Percentage of the ratio is taken for the calculation.

$$\text{Efficiency} = \frac{\text{Actual Work done}}{\text{Heat Energy consumed}} \times 100$$

$$\eta = \frac{W}{H} \times 100$$

η = Effeciency

W = Work done by the engine

H = Heat energy input

[‘η’ is a greek alphabet and is pronounced as Eeta. It is a symbol for efficiency]

Worked example

The efficiency of a heat engine is 25. If 50,000 Joules of heat is supplied to the engine, calculate the useful work done by the engine.

Solution

$$\eta = \frac{W}{H} \times 100$$

η = 25

H = 50,000

W = ?

$$25 = \frac{W}{50000} \times 100$$

W = 25 x 500

= 12500 Joules. (The SI unit of work is also joules)

Exercise

I. Four alternatives are given to each of the following statement or question. Select the correct alternative.

1. The energy transformation in a heat engine is,
   a. mechanical into heat.
   b. heat into mechanical.
   c. mechanical into potential.
   d. mechanical into chemical.

2. Forward movement of a piston in steam engine is called,

   a. expansion stroke. b. exhaust stroke.

   c. intake stroke. d. ignition stroke.

3. In a steam engine the steam cylinder is connected to the condenser by,

   a. piston. b. crankshaft.

   c. outlet valve. d. inlet valve.

4. Both the valves of a petrol engine are closed and piston moving towards spark plug during,

   a. intake stroke. b. exhaust stroke.

   c. compression stroke. d. expansion stroke.

5. An engine is designed to convert 20% of heat energy into work. If the steam in the engine has 80 K J of heat energy, the useful work done by the engine is,

   a. 16 K J b. 100 K J c. 40 K J d. 50 K J

6. In a temporary forest camp, the best way to generate electricity for several hours is, to use the following engine.

   a. steam engine.

   b. petrol engine.

   c. hand operated dynamo.

   d. diesel engine.

II. Fill in the blanks :

1. The part of a petrol engine in which petrol vapour and air are mixed is ____________ .
2. Linear movement of the piston in a heat engine is converted into circular motion by ____________ .
3. The stroke of a heat engine in which outlet valve opens is ____________ .

4. Internal combustion engine that does not use spark plug is called _____________ .

5. The fuel used in Raichur thermal power plant is _____________.

III. Answer the following

1. An engine is 40% efficient. What is the meaning of this statement?
2. Make a list of the differences between petrol engine and diesel engine.
3. Make a list of the limitations of a steam engine.
4. Explain the intake stroke of a petrol engine.
5. Diesel engines do not require spark plug. Why?
6. Draw a neat diagram of expansion stroke of a steam engine.
7. Draw a neat diagram of petrol engine and label the parts.
8. The efficiency of a heat engine is 10. If the heat energy consumed by the engine is 250 K J, how high would this engine lift an object of mass one kilogram from the ground?

   (Assume that $g = 10\ \text{m s}^{-2}$. Remember : $w = mgh$)
9. Ever increasing number of internal combustion engine vehicles is one of the causes of air pollution. How can it be controlled? What are the alternatives? Write an essay of about half a page on this.
10. If non renewable sources such as petrol and diesel, get depleted over a period of time, how to run heat engines? Write an essay on this in about half a page.

CHAPTER 10

NUCLEAR ENERGY

After studying this chapter you

- recall the phenomenon of radio activity.
- recall that radioactivity is a nuclear change.
- distinguish between nuclear reactions and chemical reactions.
- explain the meaning of nuclear energy.
- give example for nuclear fission reaction.
- explain the chain reaction of nuclear fission.
- draw the diagram of nuclear power reactor.
- explain nuclear fusion with an example.
- relate the energy of nuclear fusion reaction to the origin of energy of sun and stars.
- distinguish between nuclear fission and nuclear fusion.
- write the equations of nuclear reactions.
- state the precautions to be taken in handling and disposal of nuclear energy fuels.
- appreciate the progress made by India in harnessing nuclear energy.

In our daily life, we often hear about the subjects such as, load shedding, energy crisis and dependence on renewable sources of energy. At school level also, these are some of the topics, on which debate is organised. Why?

Traditionally used sources of energy like wood, coal and petroleum are not sufficient to meet the ever increasing demand for energy. The shift from dependence on nonrenewable sources of energy to dependence on renewable sources of energy is inevitable.

Use of solar energy and wind energy are being popularised. Also there is an attempt to find alternate sources of energy such as ethanol and biogas. In modern days harnessing of nuclear energy has emerged as an alternate source of energy.

You know that nucleus of an atom is very small. How can energy be obtained from the nucleus? What is nuclear energy? How is it different from other forms of energy? You will study about these topics in this chapter.

You have already studied about the phenomenon of radio activity. Recall the following surprises.

i) Charged particles emerge from neutral atoms.

ii) The radio activity is a nuclear phenomenon.

iii) During radio activity, an atom gets transmutated into another along with the emission of charged species (Gamma emission is an exception). An element is transmutated into another.

Can we hit the nucleus of an atom with a charged particle and bring about transmutation? It is a curious question. But the answer was found surprisingly. Ernest Rutherford was trying to find the range of alpha particles in air. He found that the range implies the maximum distance at which we can expect radiation to reach. Corresponded to that of protons. This was due to the following nuclear reaction.

$${}_7N^{14} + {}_2He^4 \rightarrow {}_8O^{17} + {}_1H^1 \text{ (proton)}$$

This was the first nuclear reaction achieved. Afterwards, many nuclear reactions were achieved. The main advantage of nuclear reaction is the production of isotopes, both radioactive and non radioactive. When the radioactive isotope is generated during the nuclear reaction, it is termed **artificial radioactivity**. For example phosphorus that occurs in the nature in the form of compounds, is not radioactive. If aluminium atoms are hit by alpha particles, we get phosphorus atoms which will be radioactive.

Nuclear reaction is a chance reaction and hence products obtained are very less.

The biggest crisis in the case of nuclear reaction is its sustenance. The reaction will not continue due to the chance reaction. Hence it was believed that nuclear reactions were of academic interest and were not of practical importance.

The situation took a ‘U’ turn when the Nuclear chain reaction was discovered in case of nuclear fission.

Thus one can think of Nuclear fission and fusion as a sustainable nuclear reactions. They can be used as a source of energy if carried out.

Let us consider fission as chain reaction

In the year 1939, it was discovered that the uranium -235 isotope changed in an exceptionally different way when bombarded by neutrons. Instead of emitting a small particle or radiation as in radioactivity, the uranium nucleus was found to break up into two large fragments. In the process, a very large amount of energy, about 200 Mev was released. **“This process of splitting a heavy nucleus into two medium sized nuclei by bombarding it by a neutron along with enormous amount of energy with 2-3 neutrons is called nuclear fission”** The neutrons released in the process bring about fission in other nuclei and results in setting up a chain reaction.

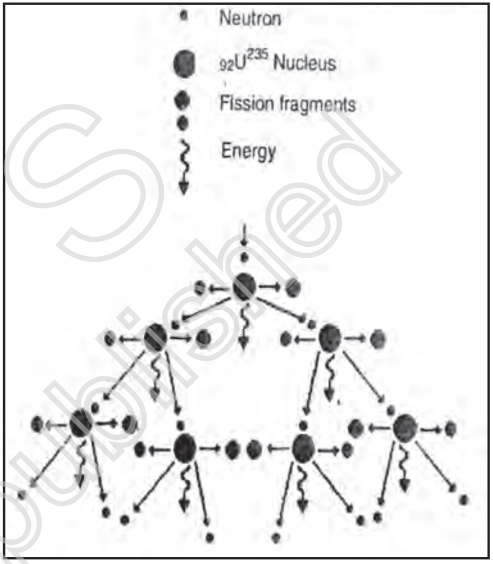


Fig. 10.1 schematic representation of a typical nuclear fission chain reaction

“A chain reaction is that process in which with the release of two neutrons and number of neutrons keep on multiplying after each fission rapidly in geometric progression, till the whole of the fissionable material is disintegrated”.

$${}_{92}U^{235} + {}_{o}n^{1} \rightarrow {}_{56}Ba^{142} + {}_{36}Kr^{91} + 3\,{}_{o}n^{1} + \text{energy.}$$

In the chain reaction if the number of neutrons produced is kept constant then it is called controlled chain reaction. If it is not controlled, the chain reaction enhances the number of neutrons and leads to explosion. In nuclear reactors, the chain reaction is controlled, where as in nuclear bomb or atom bomb it is uncontrolled.

Know this

During the second world war Japan was bombarded by two atom bombs. The bombs were named, ‘Little boy’ and ‘Fat man’.

Activity 10.1

Collect information about the different kinds of radiations released by these bombs and the temperature range near the place of bombings. Collect information about the hazards of the nuclear weapons.

Naturally occuring uranium contains about 0.7% of ${}_{92}U^{235}$ isotope which is fissionable. Self sustained chain reactions are not possible in natural uranium which is mostly made up of isotope ${}_{92}U^{238}$. To make it fissionable ${}_{92}U^{235}$ content of the ore is to be enriched, by reducing the concentration of ${}_{92}U^{238}$ isotopes. This process is known as **enrichment of uranium**. It is a complex and expensive process. The principle of Graham's law of diffusion is also applied in the process of enrichment of uranium. How? Find out.

Energetics of nuclear fission

Energy is liberated during nuclear fission since the mass is transformed into energy.

Earlier, based on theoretical consideration of relativity. Albert Einstein derived an equation which is related to the mass transformed into energy and the amount of energy released. The equation is given by

$E = mc^2$ $\quad$ E = energy released in joules

M = mass transformed in kilograms

C = velocity of light 3×10^8 m s^{-1}

Let us presume one a.m.u of mass gets converted into energy. Then it is possible to calculate the energy released in joules.

1 a.m.u = 1.66×10^{-27} Kg.

$E = mc^2$

$E = 1.66\ 10^{-27} \times 3\times10^8 \times 3\times10^8 = 14.94 \times 10^{-11}$ joules.

It is convenient to express energy in terms of electron volt. (ev) or million electron volt (Mev). The conversion factor is,

1 Mev = 1.6×10^{-13} joules

Energy released by 1 a.m.u of nuclear mass

$$E = \frac{14.94 \times 10^{-11}}{1.6 \times 10^{-13}}$$

E = 933.75 Mev

Know this

For nuclear reactors even 99.99% pure uranium metal is not useful. The useful fissionable isotope, ${}_{92}U^{235}$ has to be separated from heavier isotopes. This process is called enrichment of uranium. Uranium is converted into uranium hexofluoride gas and repeatedly diffused. The lighter isotope diffuses first leaving behind heavier isotopes.

Practical consideration has been made to calculate 1 a.m.u to release energy, equivalent to 931 Mev. Approximately, one electron volt means the energy gained by the electron when it is accelerated by applying a potential difference of one volt.

Controlled nuclear reactions

The process of nuclear fission reaction produces more than two neutrons. Excess of neutrons are absorbed so that the number of neutrons per fission is regulated to around one neutron per fission. this is controlled fission reaction.

Analogy : LPG is highly combustible. If accidentally, it catches fire, causes only destruction. The energy is not useful. But the same LPG can safely be used in the stoves by regulating the rate of combustion.

Nuclear reactor

The device used to carry out the fission under controlled condition is called a nuclear reactor. There are three important types of nuclear reactors. They are

1) Breeder Reactor [To produce radio isotopes]
2) Power Reactor [To generate electricity]
3) Research Reactor [To carry out research programmes related to atomic energy]

In this chapter we shall study about the main features of a nuclear power reactor.

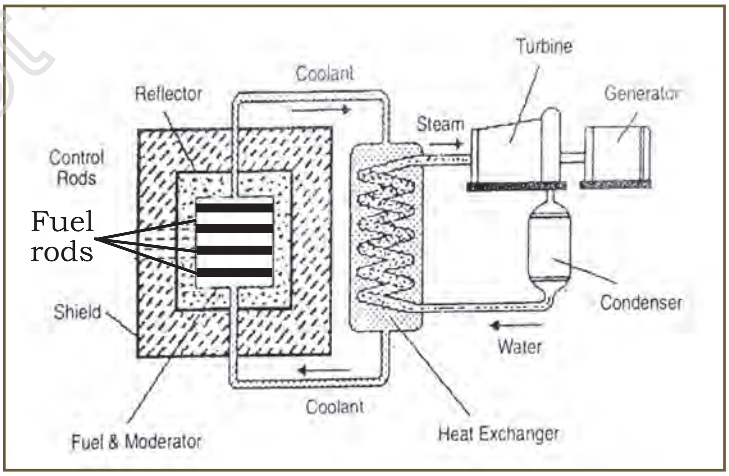


Fig. 10.2 Schematic diagram of a nuclear power reactor

Nuclear power reactors are very large reactors in which heat generated by nuclear fission is removed by water and the resulting steam is used to drive a large turbine connected to a generator.

Nuclear Fuel

The fissionable material used in the reactor is termed as nuclear fuel. One such fuel is enriched uranium containing higher percentage of $_{92}U^{235}$ isotope There are other fissionable materials like plutonium, which are used in nuclear reactors. The fuel is generally in the form of rods placed in a regular array in a large container. This constitutes the core of the reactor.

Control Rods

Control rods are made up of cadmium or boron carbide, which absorb neutrons efficiently. The depth to which these rods are inserted in the reactor core, decides the number of neutrons available for fission at any time. A nuclear reactor can also be shut off by inserting the rods sufficiently deep. The reactor is said to be **critical** when the number of fissions per unit time remain constant. This is achieved by increasing or decreasing the depth of the control rods in the core.

Moderator

The fuel rods are surrounded by a moderator whose main purpose is to slow down neutrons emitted in the fission process. The slow moving neutrons are more efficient in inducing fission. Heavy water and graphite are commonly used as moderators.

Know this

The molecular formula of heavy water is H_2O, But it is made from deuterium isotope of hydrogen $_1H^2$, It is also represented as D_2O. Its molecular mass number is approximately 20. Ordinary water contains a very small quantity of heavy water. [Approximate ratio 1:6000]

Reflector

Reflectors keep the neutrons confined to the core as much as possible. A moderator can also be used as reflector.

Coolant

The large amount of energy released during the fission process appears as heat. This must be removed continuously by a coolant is also called heat exchanger because it transfers the heat of the reactor to water to produce steam. Liquid sodium metal, high boiling point hydrocarbons, heavy water are some of the coolants.

Generation of electricity

The pressure of the steam is used to rotate the turbines which are attached to generators.

Radiation shield

The reactor as a whole must have a very efficient and reliable radiation shield. This is to protect people in the vicinity of the reactor against the harmful effects of nuclear radiation arising from the radioactive decay of the many products of fission. A thick layer of lead surrounded by very much thicker wall of concrete, act as an effective shielding.

Know this

Moderators are not used in fast nuclear reactors and IV generation nuclear reactor, since slowing down of neutrons is not needed.

Atomic energy in India

Bhabha Atomic Research centre [BARC] is the major centre for research and development work in atomic energy in India. The first atomic power station in India called **Tarapur atomic power station** started working in 1969 in Maharashtra.

India's uranium supply comes mainly from Jaduguda mines in Bihar. India also imports enriched uranium from developed countries.

Kota (Rajasthan), Kalpakkam (Tamil Nadu), Kaiga (Karnataka) are the places where nuclear power reactors are functioning.

Activity 10.2

On a map of India, locate the places where the nuclear power reactors are setup.

Nuclear Fusion

Under specific conditions, nuclei of light elements can combine to form a nucleus of high atomic number. **The process by which two or more nuclei of lighter atoms combine to form a heavy nucleus with the liberation of large amount of energy is called 'Nuclear fusion'**.

EXample : ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + \text{Energy}$

Deuterium isotope of hydrogen nucleus	+	Deuterium isotope of hydrogen nucleus	→	Helium nucleus	+	Energy

As we know, the sun and the stars are sources of enormous amounts of energy, produced continuously for billions of years. What is the mechanism for production of this energy? The energy comes from the fusion of lighter nuclei into heavier nuclei. These reactions are called Thermonuclear fusion reactions. A self sustaining, controlled and economically viable process of thermonuclear fusion is still under experimentation. At present, it is not possible to use fusion energy for peaceful purposes.

Differences between Nuclear Fission and Nuclear Fusion

Nuclear Fission	Nuclear Fusion
1) A heavy nucleus is split into two lighter nuclei with the liberation of energy and neutrons.	1) Two or more lighter nuclei fuse to form a heavy nucleus with the liberation of energy.
2) Nuclear fission reactions can be controlled.	2) At present, there is no mechanism to control fusion reactions.
3) The process of fission does not require high temperature.	3) The process of fusion requires extremely high temperature of the order 10^6 K.
4) Causes radiation pollution problems due to radioactive products	4) Does not cause radiation pollution since the products are not radio active.

Know this

If fusion reaction can be produced in the laboratory, in a controlled way, there will be no energy crisis!

Nuclear weapons

Based on the principle of nuclear fission and nuclear fusion, there are atom bomb (fission bomb) and hydrogen bomb (fusion bomb). They are weapons of mass destruction and their use and control has been a major aspect of international policy. Albert Einstein remarked "---If the third world war is fought with nuclear weapons, the fourth world war will be fought with stones--" Scientists and Humanists with social concern always oppose the use of nuclear weapons.

Handling and disposal of nuclear materials

Radioactive materials are hazardous to human health if adequate precautions are not taken in handling their sources. People or living organisms in the vicinity of these materials will be exposed to radiations. Especially ionising radiations like gamma rays can cause mutation in the living cells and can cause DNA alterations. [Madam Curie isolator of radium, suffered from cancer due to the long exposure to radiations]. Certain types of cancer and hereditary disorders are caused by ionising radiations.

The material left behind the nuclear reactor is also radioactive. The radioactive material with short half life is of severe concern immediately. But the radioactive materials of long half life is dangerous in the long run since the radioactivity lasts longer.

The radioactive matter is impregnated in glass slabs and disposed in the deep sea in strong steel containers, so that radiation can not reach the level of Biosphere or diffusion of radioactive material can not reach the level of Biosphere. The Radiations of radioactive materials are invisible. Our sense organs can not feel the radiations. Precautions such as lead jacket are necessary for the workers in the nuclear laboratories.

Activity 10.3

i) Figure No 10.3 is a symbol. In the periodic table which elements have this symbol? [In the periodic charts displayed in your school]

ii) The symbol is also an indication of warning. What is the warning?

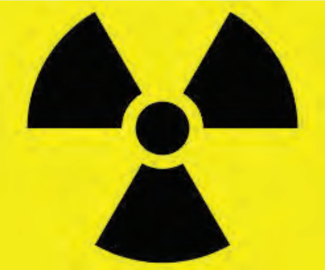


Fig. 10.3 Symbol to show the presence radio active material

Activity 10.4

i) Collect information of chernobyl and Japan nuclear disasters.

ii) Collect pictures of disaster caused by atom bomb in Hiroshima and Nagasaki of Japan during second world war.

iii) Make a list of the health hazards caused by harmful radiations collecting information from the internet.

Know this

How are nuclear reactions different from chemical reactions? The following table summarises the differences.

Chemical reactions	Nuclear reactions
1) Valence electrons of the atoms participate in the reaction.	1) Electrons of an atom have no role to play in nuclear reactions.
2) Nucleus of an atom does not undergo any change.	2) Nucleus of the atoms undergo a change.
3) Products are predictable.	3) Nuclear reaction is a chance reaction. Products depend upon conditions.
4) Mass is conserved.	4) A small amount of mass is converted into energy.
5) Inter conversion of compounds to elements or elements to compounds take place	5) Production of new elements and isotopes take place which is called transmutation.

Exercise

I. Four alternatives are given to each of the following statement or question. Select the most appropriate alternative :

1. Which of the following source of energy is not considered as the transformation of solar energy?

a. energy of food	b. energy of petroleum
c. energy of coal	d. energy of fission

2. Which of the following is a nuclear reaction?
   a. two hydrogen atoms combine to form hydrogen molecule.
   b. sodium atom gives up an electron to become sodium ion.
   c. water splits up into hydrogen and oxygen by electrolysis.
   d. isotopes of Hydrogen nuclei combine to form helium nuclei.
3. The equation $E = mc^2$ was theoretical. It received experimental proof from,
   a. nuclear reactions carried out in the laboratory.
   b. measurement of molecular mass of a compound formed by chemical combination.
   c. measurement of molecular mass of products of decomposition.
   d. the phenomenon of radioactivity.
4. Transmutation means,
   a. conversion of one element in to another
   b. conversion of charge number of an atom
   c. mass and energy are inter convertible
   d. creation of neutrons by fission
5. Nuclear power reactor is based on the principle of,
   a. exothermic chemical reactions
   b. endothermic chemical reactions
   c. controlled nuclear fission
   d. thermonuclear fusion
6. The nuclear fission chain reaction is initiated by the particle,
   a. proton b. neutron
   c. electron d. positron

II. Fill in the blanks

1. Fissionable isotope of uranium is ________________ .
2. Increasing the percentage of fissionable isotope of uranium in the natural uranium is called ________________ .
3. The most dangerous radiation released by radioactive materials is ________________ .

4. The equation E = mc^2 is derived by the scientist ____________ .

5. The nuclear reaction that can not be controlled at present is ______________ .

III. Match the following

	A		B
1.	$_{92}U^{235}$	a.	Nuclear fusion
2.	Graphite	b.	Nuclear fuel
3.	Control rod	c.	Moderator
4.	Radiation shield	d.	Cadmium
		e.	Lead and concrete
		f.	Liquid sodium
		g.	Liquid hydrocarbon

IV. Answer the following

1. Draw a neat diagram of nuclear power reactor and label the parts.
2. Draw the schematic diagram of fission chain reaction of $_{92}U^{235}$ isotope.
3. State any two places in India where the nuclear reactors are functioning.
4. State the precautions to be taken, while handling nuclear reaction materials.
5. How should the spent fuel of a nuclear reactor be disposed?
6. Explain nuclear fission with an example.
7. Explain nuclear fusion with an equation.
8. State any two differences between chemical reactions and nuclear reactions.

CHAPTER 11

INDUSTRIAL INORGANIC CHEMISTRY

(A) GLASS

After studying this chapter you

- list the unique properties of glass which make it a popular substance.
- list the major advantages of glass articles when compared with other metallic containers.
- recall the raw materials which are used in the manufacturing of glass.
- describe the steps of manufacturing of glass.
- list the types of glasses.
- list the uses of different types of glasses.

Fig 11.1 Laboratory

Look at the picture of a laboratory. Many equipments are made up of glass including the spectacles. Many experiments are conducted in the field of science using glass.

Man has been using glass since ancient times. There are many references for this in history and mythology. Although glass is a commonly used substance today, it was a rare commodity during the ancient times.

At that time, it was considered to be a valuable gem. Man discovered glass accidentally. Some traders, while cooking on the sand of the desert, had supported their pots on pieces of lime stone rock. On taking away the pot, they found a newly formed transparent substance. They conjectured that this substance had been formed because of heating lime stone and sand together. May be baking soda also had a role. This led to the development of the technique of manufacturing glass.

Glass appears as a solid, amorphous and hard but brittle material, made from silica and silicates. Though glass has the properties of solids, but it has the randomness in the arrangement of molecules, like a liquid and hence it is considered as super cooled liquid.

Note

Glass is transparent for visible light radiation but not for infra red rays.

Glass is mainly made up of sodium and calcium silicate. Let us learn about the preparation of glass.

MANUFACTURE OF COMMON GLASS

Raw Materials

a) Soda ash (Na_2CO_3)

b) Lime stone ($CaCO_3$)

c) Sand (SiO_2)

d) We can also add pieces of broken glass to increase the fusibility and to recycle the broken pieces of glass [up to 25%].

Know this

Technology for the conversion of glass (not recycled) into a harmless shape is available now and in use.

Manufacturing Stages

i) **Melting** Raw materials in proper proportions are mixed with cullets (glass pieces) are finely powdered and mixed. The intimate mixture is fused by heating it in a furnace, at high temperature (about 2073K) the charge melts and the following chemical reactions take place.

$$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2 \uparrow$$

$$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2 \uparrow$$

When all the carbon dioxide escapes out of the molten mass, decolorizers (such as manganese dioxide) are added to get away with ferrous compounds and carbon, if present. If a coloured glass is desired, the colouring agents (some metallic compounds) are added at molten stage. It is then cooled.

Activity 11.1

Observe a cheap, used, thick medicine bottle, carefully. It has a wavy structure and inner layer is not uniformly set. It is because, such glasses are not annealed properly. Spectacle glass is annealed for more than 8-10 hours. There is proper alignment of molecules in this type of glass.

ii) Shaping

Molten glass is then worked into articles of desired shapes by either blowing or moulding or pressing between rollers.

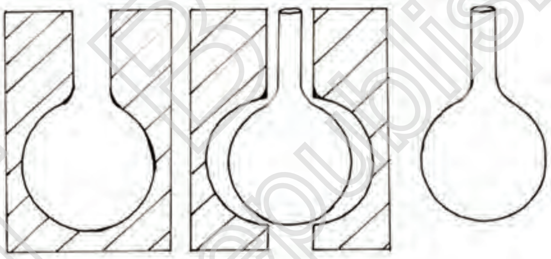


Fig. 11.2 : Giving desired shape to glass articles

Know this

Glass articles are made by blowing method. A small amount of glass is fixed to the end of a long blowing pipe and heated. A small bulb is formed when air is blown from the other end. By rotating the pipe, the required shape is given to the glass. The glass bulb is kept in a mould and blown again to acquire the required shape.

Fig. 11.3 Blowing Method

iii) Annealing

Glass articles are then allowed to cool gradually to room temperature by passing through different chambers with descending temperatures. If allowed to cool rapidly, glass being bad conductor of heat, the superficial layer cools down first leaving the interior portion in a state of strain. Owing to this unequal expansion, the articles are likely to crack into pieces.

The process of **gradual cooling** of glass articles to room temperature is called **annealing**.

Know this

To remove the air bubbles in glass, borax or aluminium powder is added to the glass and heated slowly. The air bubbles escape from the glass in this process. Aluminum powder/Borax settles at the bottom and hence it can be easily separated.

iv) Finishing

All glass articles after annealing are subjected to finishing processes such as cutting, grinding and polishing.

Activity 11.2

When a glass object is held in a flame, flame acquires golden yellow colour. The sodium content of the sodium silicate present in glass is responsible for this.

Properties of glass

Glasses are widely used because of the following properties :

1. They are chemically resistant. Glass containers can hold aquaragia. (Conc HCl and HNO_3 in the ratio of 3:1) which can dissolve gold.
2. Glass is shining because of smooth surface, further it can be brightened by polishing. Glass can have a smooth surface which can be polished.
3. Glass can be moulded into different shapes conveniently.
4. Glass can be coloured.
5. Glass is transparent.
6. Glass can be moulded to produce designs.
7. Properties of glass can be altered suitably by including additives.
8. The transparent nature can be made automatically adjustable to the intensity of light.

Glass is very cheap substance, because, the raw materials are cheap and almost available in most of the geographical areas. Sophisticated technology is not required to manufacture glass. Glass articles are produced in a cottage industry which is very much popular in Uttar Pradesh [Gaziabad].

On heating, first glass becomes soft. You might have observed this phenomenon while making garlands out of pieces of bangles by heating them in a candle flame. Because of easy softening on heating, the glass can be given any desired shape. Glass does not have fixed melting point. It melts over a range of temperature.

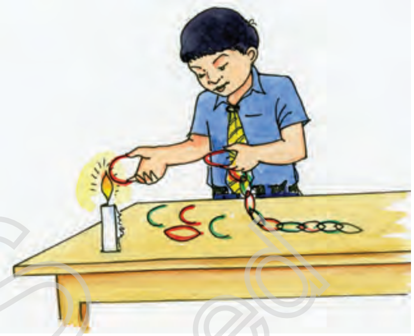


Fig. 11.4
Heating a piece of glass

OBSERVE

Etching of glass *Hydrogen Fluoride / Hydrofluoric acid is a chemical that reacts with glass. With this, acid glass articles are decorated. The part which is to be decorated is made to react with the acid. This is called etching of glass.*

Glass is a bad conductor of heat but expands easily on heating. That is why it cracks if it is suddenly heated or cooled, due to rapid expansion and contraction simultaneously along the hot region and cold region respectively.

There are limitations for glass also. It is brittle and dense. Now a days the glass is being replaced by not so heavy and transparent polymers like poly methyl methacrylate polymers. Scratches on this transparent polymer can be easily wiped out by Acetone. It is less brittle compared to glass.

Activity 11.3

Immerse a glass bottle in a vessel containing water. Heat the vessel slowly. The bottle does not break even if the water begins to boil. Why?

Fun

Immerse a glass test tube in a mixture of acetone and chloroform in suitable proportion. You will find the apparent disappearance of glass immersed in the solution. This is because of the almost same refractive index of glass and solution. When refractive index is same, the surface of glass will not reflect light.

COLOURED GLASS

The soda -lime glass is colourless. In order to impart colours to it, compounds of certain metals are added to the molten mixture while making the glass. These compounds impart specific colour to the glass.

Yellow - Ferric compound
Green - Ferrous and Chromium compounds
Blue - Cobalt compounds
Red - Nickel Salts or Cuprous compounds

OBSERVE

The broken edges of common glass have a slight greenish tinge. It is because, any sample of common sand contains some amount of iron salts.

Note

NANO TECHNOLOGY AND GLASS

Recently Prof. C.N.R. Rao of J.N.C.A.S.R. (Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru) was honoured by awarding Bharat Ratna. He has published many research papers. One of his research areas is Nano technology. Nano means particle size of 10^{-9} *m. Nanotechnology is one of the most developing research areas in science.*

The history of Nano materials can be found during the Roman period. Even at that time, colloidal metals were used to dye glass.

Romans were skilled at impregnating glass with metal particles to achieve variety of effects. Clearly, the ability to synthesize nanocrystals preceded the understanding of the nanoscale phenomena.

Think

Collect the coloured bangle pieces. Powder them. See the change in colour. Can you reason. Why?

Activity 11.4

Take around 100 cm^3 of water in a 500 cm^3 beaker. Immerse an empty test tube vertically as shown in figure. You will be surprised to see the shiny surface of test tube inside the water as if surface is silvered. Fill test tube with water the shiny surface disappears. Reason out why?

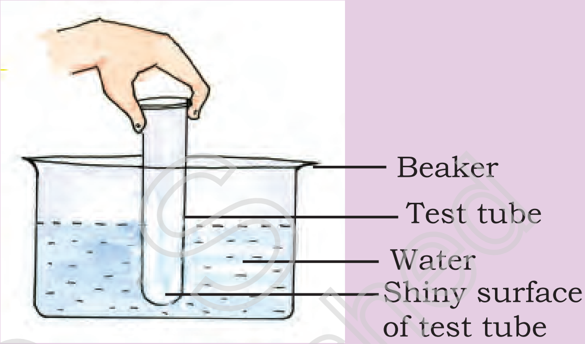


Fig. 11.5

TYPES OF GLASSES

1. Soda - lime glass

It is low in cost and relatively resistant to water. It melts easily.

Use : It is widely used as window glass, electric bulbs, plate glass, bottles, jars, building blocks and cheaper table wares.

Think

Glass plates which are fitted to window frames of some buildings have a speciality. A standing person outside cannot see the inside of the building. But a person who is inside the building can observe the outside articles. The same principle is applied in the wind screens of some cars. Use the knowledge of reflection and refraction of light

Collect the information about Green house.

2. Potash lime/hard glass/Bohemian glass

This type of glass is prepared from silica (sand), calcium carbonate and potassium carbonate. It possesses high melting point and it fuses with difficulty.

Use : Potash lime type of glass is used for preparing chemical apparatus, combustion tubes.

3. Lead glass / Flint glass

This is made by using lead oxide instead of calcium oxide for fluxing together with silica.

Use : Lead glass is used widely for the manufacture of high optical purposes (like lenses), neon sign tubings, cathode ray tubes, electrical insulators.

OBSERVE

Observe the darkening of glass when exposed to sunlight and the same glass becomes clear in a dark environment. Photosensitive substances interact with light and undergo chemical reaction leading to this effect.

4. Borosilicate glass / Pyrex glass / Jena glass

This is the most common of the hard glasses used for commercial purposes. Such glasses virtually contain only silica and boron with a small amount of alumina and less alkaline oxides.

Use : Borosilicate glass is used extensively in industry for the preparation of pipelines, superior laboratory apparatus.

5. Safety glass

This is made by sandwitching thin layer of synthetic vinyl plastic in between two or three flat sheets of glass and then it is subjected to slight pressure. It is then heated till the glass layers and plastic layers merge into one another. On cooling, the glass becomes quite tough. When such a glass breaks, it does not fly into pieces as the inner plastic layer tends to hold back the broken pieces of the glass. It is mostly used in automobile and aeroplane industries as wind shield.

OPTICAL FIBRE

Optical fibre is a flexible, transparent fibre made up of very pure glass, not much wider than a human hair that acts as a wave guide or light pipe, to transmit light between the two ends of the fibre.

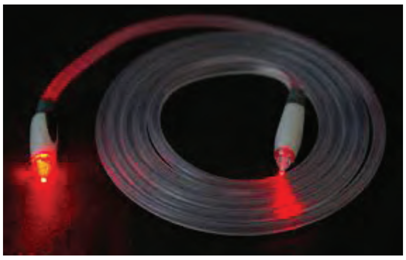


Fig. 11.6 Optical fibre

Recall

Optical fibres have two transparent layers of different refractive indices. The outer layer has higher refractive index than the inner layer. Remember the condition for total internal reflection of light to take place. Can you state the condition?

Optic fibre can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. It is more advantageous to long distance communications, because, light propagates through the fibre.

> ***Note***
>
> *Communication using electron is termed Electronics. Communication using photon and optic fibre is known as photonics.*

Consider the following merits.

1) Since optic fibre does not interact with air or water, it never corrodes.
2) Message reaches the destination much faster since photons transmit much faster than electrons.
3) Optic fibres can transmit more messages at once, compared to transmission by electron in a wire.

Exercise

I. Four alternatives are given to each of the following incomplete statement / question. Choose the right answer:

1. The another name of flint glass is

   a. soda lime b. potash lime
   c. lead glass d. borosilicate glass

2. During manufacture of glass, which material is used to increase the fusibility?

   a. soda b. lime stone c. sand d. cullets

3. Glass will crack if it is suddenly heated or cooled, because of its ____________

   a. bad conducting nature and high co-efficient of expansion
   b. transparency
   c. plasticity
   d. density

4. $CaCO_3 + SiO_2 \rightarrow$ ____________

   a. $CaO + SiCO_3$ b. $CaSiO_3 + SiO_2$

   c. $CaSiO_3 + CaO$ d. $CaSiO_3 + CO_2$

5. Which type of glass is used to prepare lenses?

   a. lead glass b. borosilicate glass

   c. soda - lime glass d. safety glass

II. Fill in the blanks with Suitable words

1. The decolourising substance ___________.
2. The raw materials used in glass manufacture are soda, lime stone and ___________.

III. Match the following

A	B
1. yellow colour glass	a. calcium phosphate
2. green colour glass	b. manganese dioxide
3. blue colour glass	c. cuprous compound
4. red colour glass	d. chromium compound
	e. cobalt compound
	f. ferric compound
	g. magnesium compound

IV. Answer the following

1. List any four properties of glass.
2. State the uses of the following glasses.

   a) Borosilicate glass b) Lead glass

3. Give reason

   a) Annealing process is carried out in glass manufacture.

   b) Vinyl plastic is used in preparing safety glass.

4. Write a note on optical fibre.

* * *

(B) CERAMICS

After studying this chapter you

- list the raw materials which are used in the manufacture of ceramics.
- describe the steps of ceramic manufacture.
- list the uses of ceramics.

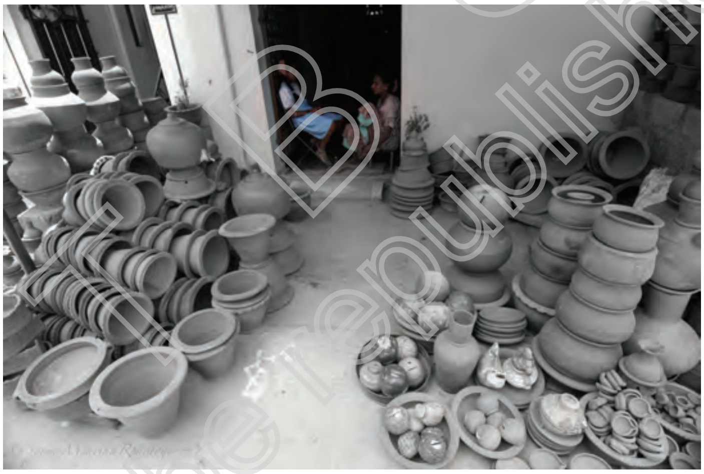


Fig. 11.7 Pottery shop

In the above picture you find a potter's shop containing articles made up of clay. Visit a potter. Watch how a potter mixes clay and water, moulds it into different shapes. Such materials prepared out of specific mud are called ceramics.

Note

Water takes the shape of pot, the container. Water renders clay plastic when mixed with water and responsible for shaping the pot.

But the pots made here are porous and do not have attractive colour. These are mainly used as containers. Pots with porocity will keep the water stored cool.

See these shining and non porous artiles. They have smooth and bright surface. They also have attractive colours. The process of manufacturing the clay product into non porous shining material is called Glazing.

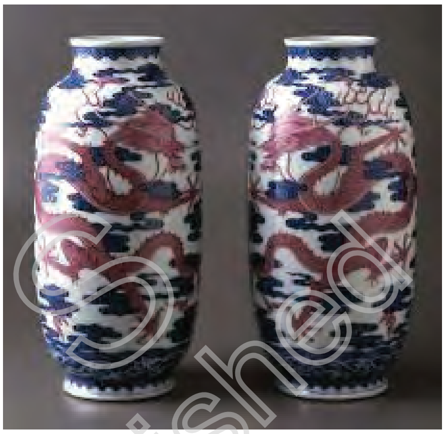


Fig 11.8 Ceramic articles

Note

Dishes made out of glazed clay of China are used in laboratories and they are known as China dish. They are brittle but they are heat resistant and non corrossive to chemicals.

Find out

What is the meaning of English Idiom ***Bull in a china shop****?*

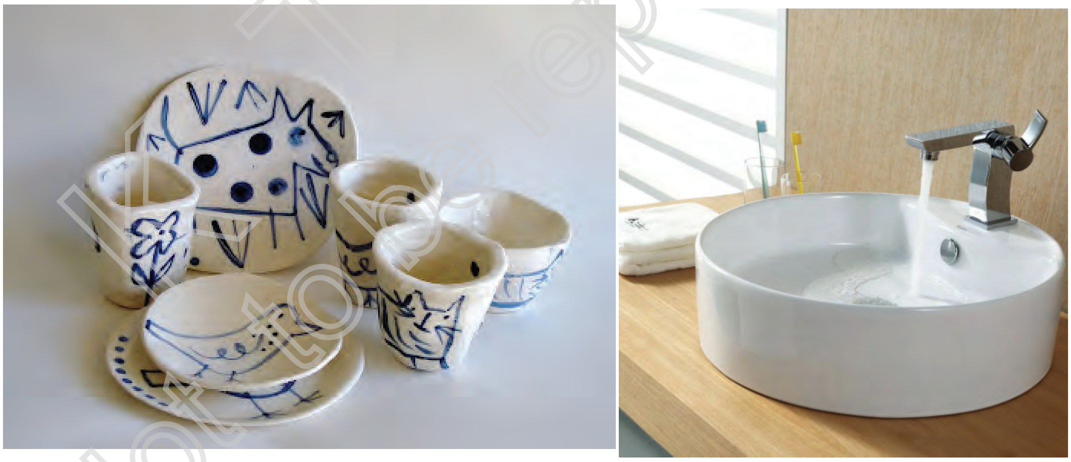


Fig 11.9 Ceramic articles

Be it a crude pot or tile, the raw material and the process is the same, hence they are called ceramics.

Ceramic substances are not new. In fact, our ancestors discovered ceramics thousands of years ago. The word 'Ceramics' is derived from the Greek word 'Keramos' meaning burnt earth.

The earliest ceramics were pottery and other objects made from clay itself or clay mixed with other materials, hardened in fire. Such materials were rough and porous. Smooth and non porous ceramics are produced by glazing. This is achieved by addition of suitable fillers, fired to create a coloured, smooth surface. Ceramics now include domestic, industrial and building products and artefacts. Now- a- days new ceramic materials are developed for use in advanced ceramic engineering for example, in semiconductors.

Think

Unglazed ceramic materials are used in water filters. Why?

Manufacture

Raw Materials used

- Clay like kaolinite and bentonite
- Flint
- White clay
- Quartz
- Feldspar

Know this

Aqueous Clay is a naturally occuring thermally setting substance. It can be moulded to any desired shape. It becomes hard and brittle On heating but can retain its shape. It is a complex mixture of silicates.

Cooking vessels and roof tiles were exclusively prepared out of clay.

Ceramics familiar to you are-Earthern Pots. Recall how they are prepared. The clay is mixed with required quantity of water so that it acquires plasticity. The desired shape is given using the specific device.

The wet clay after shaping is heated in a kiln. This leads to partial elimination of water during which it generates invisible holes.

Fig. 11.10
A 'potter' at work

Recall

The preparation of 'Dosa' ends up with visible holes during the escape of water in the form of steam.

Think

Why ceramic pottery forms very tiny and invisible holes and not big holes?

Water preserved in pots have a distinct feature.

Ceramics are not prepared with clay only. Some earths like kaolinite and bentonite are also substitutes. Any way these have similar property- i.e. plasticity when mixed with required quantity of water.

Note

For easy shaping of objects, kaolinite and bentonite are ideal.

Cracking of ceramic articles could be controlled if some non-clay materials like flint and quartz are added to the mix. Flint and Quartz are different forms of silica which do not absorb water. Since they do not absorb water, they also do not get transformed on heating and hence, do not shrink. The pottery made from a mix of clay and flint or quartz is porous. The water escapes from clay on heating, and makes the product porous.

If pores have to be avoided, normally one has to think of additives which are hard and water repelling.

Later it was found that if certain other materials like feldspar are added, they give a smoother glossy finish as well as added strength to the ceramic articles or materials.

Know this

Feld spar : *Naturally occurring aluminium silicate mineral containing sodium, potassium in combined form similar to clay minerals.*

Once the appropriate raw materials are chosen to get the desired finish, next step is shaping these into the needed form. This is followed by drying and firing of the shaped article which stabilises the shape. Thus, the sequence shaping-drying-firing is the characteristic of all the ceramics.

On heating the ceramic materials, at about 1073K to 1273K, they melt into a glass like liquid, which fills the pores between individual clay particles and strengthens their contact points. On cooling, this glossy material gives a shining and smooth finish to the material.

Note

Water kept in a porcelain container will not get cooled, indicating the absence of holes.

Know this

Water in a pot will be cooler because of continuous evaporation of water through pores.

Activity 11.5

Take two small pots of identical shape and size. Smear the paint on the surface thoroughly in the case of one of the pots.

Take equal quantities of water sufficient enough to fill up to the brim. Wait for about some time and dip your finger. What would you notice? Surprisingly unpainted pot will have relatively cooler water. This cooling effect is due to the evaporation of water through the pores, in case of unpainted pot. Painted pot has no holes and hence no evaporation through wall of the container and hence no cooling.

Think

Why do we experience cool environment near a tree?

Ceramic articles get coloured tinge due to the presence of some metallic oxides in the raw materials used.

Find the reason

Pickle is stored in ceramic jars but not in earthern jars. Why?

Activity 11.6

Collect lemon juice in ceramic cup and metallic cup seperately and keep it for about an hour. The juice kept in metallic cup will taste differently why?

Know this

Ceramics have excellent ability to withstand high temperature and various corroding chemicals.

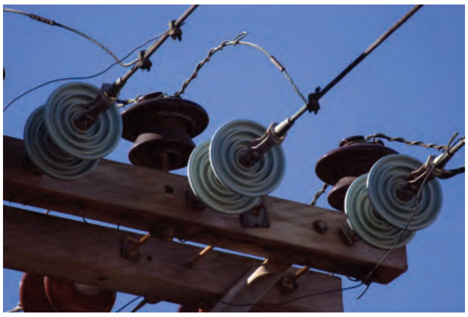


Fig 11.11 Ceramic articles used as insulaters

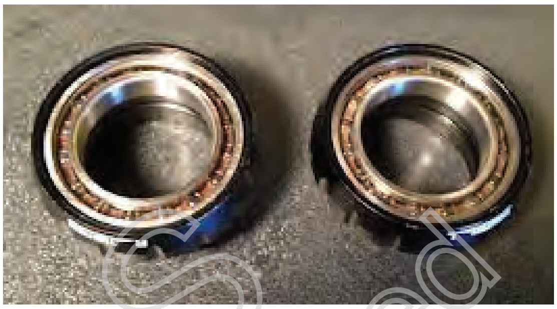


Fig 11.12 Ceramic ball bearings

- They are good at stopping the flow of electricity. Ceramic insulators soon become an essential part of electrical gadgetry.

Think

Railways have introduced paper or earthern cups to serve tea, coffee instead of plastic cups. Why?

- Ceramic balls can be used to replace steel in ball bearings.
- Work is being done in developing ceramic spare parts for gas turbine engines.
- Recent advances have been made in ceramics which include bioceramics, such as dental implants and synthetic bones.

Activity 11.7

In the musical instruments like Ghatam and Jalatarang, clay and ceramic materials are used. They can be made sonorous like metals. Take eight ceramic cups of same thickness but of different sizes as shown in fig

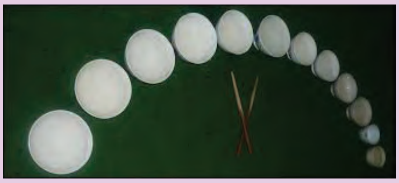


Fig 11.13

Fill water upto half of the each cup. Take a long wooden stick and strike each of the cup. Make variation in stroke and create musical note.

Exercise

I. Answer the following questions

1. Write one similar character between glass and ceramics.
2. What are the merits of glazing the earthern ware?

II. Fill the table with suitable words

Sl.No.	Additive	Advantages
1.	Clay	
2.	Flint	
3.	Quartz	
4.	Feldspar	

III. Fill in the blank with suitable answer

Sl.No.	Uses of ceramics	Reason
1.	Floor vitrified tiles	
2.	Part of electrical gadgetry	
3.	Pickle jar	

(C) PAPER

After studying this chapter you

- recall the raw materials which are used in paper making process.
- describe the steps involved in paper making process.
- realise the significance of the economy in the use of paper.
- know the benefits of recycling paper.
- list the uses of paper.

The book you read, the note book on which you write, the bus ticket, the letter for correspondence are all made of paper. In fact, 'paper' also means an article / essay written on paper. You might have come across the statements like "presented a research paper".

In the Indian languages paper is referred as 'patra' since the earlier writing was carried out on leaves.

Know this

Crude form of paper was invented by the Chinese by 105 AD

Do you Know

The word 'paper' is etymologically derived from papyros, Ancient Greek term for the cyperus papyrus plant. Papyrus is a thick, paper - like material produced from the pith of the cyperus papyrus plant which was used in ancient Egypt.

Observe

Any sheet of paper will not have identical smooth surface on both sides. One of them will be relatively smoother compared to the other.

As you know the paper is a versatile material with many uses. The most common is for writing and printing upon. Cups, bags, packing files and materials are also made of paper.

Know this

Paper is used in Origami/kirigami activities. You might have enjoyed playing with a paper rocket/ paper boat.

Normally paper is a thin material. It is produced by pressing together moist fibres, typically cellulose pulp derived from wood, rags or grasses and drying them into flexible sheets.

Let us learn the steps involved in paper manufacturing process.

1. **Pulping**

   Pulping is a process, where the wood is chipped and made into fibres. Pulp is bleached before additives are used.

2. **Mixing additives**

   Besides the fibres, pulps may contain fillers such as chalk or China clay, which improve the characteristics of the paper form printing or writing.

Then the pulp is fed to a paper machine where it is formed as a paper web and the water is removed from it by pressing and drying.

Note

Additives are not used in making blotting paper.

3. **Drying**

   This involves using air and heat to remove water from the paper sheet. In the earlier days, paper making was done by hanging the paper sheets as clothes are draped in a laundry. Now- a-days the ‘ steam heated can drier’ is commonly used for drying.

4. **Finishing**

   The paper may then undergo sizing to alter its physical properties for use in various applications. Paper at this point is uncoated. Coated paper has a thin layer of material such as calcium carbonate or china clay applied.

Activity 11.8

Collect the information about Gloss paper.

Activity 11.9

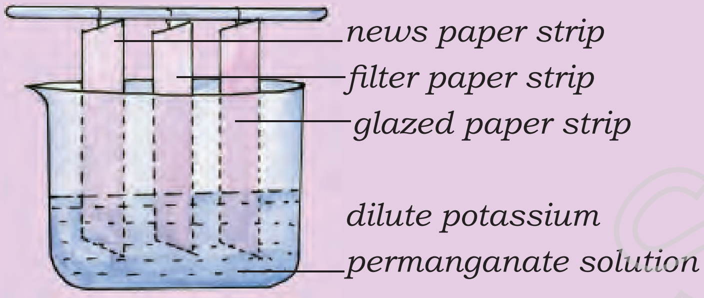


Fig 11.14

Take about 10cm^3 of dilute potassium permanganate solution in a100 cm^3 beaker. Dip strips of news paper, filter paper and glazed paper with the help of clips and stand. Observe the rise of patassium permanganate solution level in each paper samples. In which paper strip the level of potassium permanganate solution level is more? Reason your finding. The activity leads to paper chromatography technique, which you will study in higher classes.

Do you Know?

- *24 trees of 40 feet are consumed to manufacture a ton of paper.*
- *About 16.67 ream or 8333 sheets of paper can be produced from each pulping tree.*
- *A ream paper uses 6% of a tree.*
- *Paper carelessly disposed is consumed by pets frequently which leads to detrimental impact on their health.*

Activity 11.10

Collect the samples of old paper and compare the samples with fresh one. You find the increased porosity, yellowish tinge and lack of tensile strength in the old paper. Guess, why such changes have taken place.

Paper contains significant amount of lignin, a major component in wood. In the presence of light and oxygen lignin reacts to give yellow materials, that is why paper yellows with age.

Know this

Your marks card, bus pass, identity card which are printed on paper card board are laminated to avoid fading of printed matter due to the air, moisture and radiation. It is done by keeping thin sheet of polythene and gradually melting followed by solidification.

Types of paper

Filter paper : Filter paper is a semipermeable paper. It is porous in nature. It is used to separate fine solids from liquids or air.

In laboratories, filter paper is usually used with a filter funnel.

These papers may be impregnated with various reagents for use in detection tests like pH. They are used in dip tea bags. Filter papers with pores of different size are available in the market.

Activity 11.11

Take a dip tea bag. Remove the tea powder. Observe the bag with a convex lens. Hold the bag over a candle flame at a safe distance. The bag flies upwards.

Fig 11.15 dip tea bag

Tissue Paper : Tissue paper is a light weight paper or light crepe paper. Tissue can be made both from virgin and recycled paper pulp.

Tissue paper is widely used as facial tissue napkins and house hold towels.

Wax paper

Wax paper also known as paraffin paper. Paraffin paper is a paper that is made moisture proof through the application of wax which makes paper nonporous. Wax paper is commonly used in wrapping for its non sticking properties and wrapping food for storage, such as cookies, ice creams as it keeps content moisture resistant. It is also used in arts and crafts.

Fig 11.16 wax paper

Card board paper : The tensile strength of a paper is decided by its thickness. Card board paper is made hard, depending upon the requirement. The thickness is achieved as a single layer or multi layer combination. Such paper is used in post card, poster and display board drawing.

Think

Smear small quantity of oil on a sample of paper. (Note: glazed paper, thick paper should not be used) you will be surprised to know that the paper becomes translucent. Reason out why?

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There are two main limitations of paper

1) Unlike plastic, they are not perfectly non porous.

2) Their tensile strength radically reduces on wetting.

How is waste paper recycled? Collect information

The future of paper

Some manufacturers have started using a new, significantly more eco - friendly alternative to expanded plastic packaging made out of paper, known commercially as paper foam. The packaging has very similar mechanical properties to some expanded plastic packaging, but is biodegradable and can also be recycled with ordinary paper. Synthetic materials have been introduced as printing media as a more durable material than paper. Paper bags can replace plastic bags since they are eco - friendly.

Exercise

I. Fill in the blanks with suitable answer

1. The major natural polymer present in paper is _____________.
2. The coating chemical used to coat paper in the final stage of manufacturing paper is ______________ .
3. Paper turns yellowish with age due to the presence of the chemical ________________ .
4. The type of paper used in the separation of mixtures in the laboratory is _____________ .

II. Answer the following questions

1. It is easy to tear the wet paper instead of dry paper. Why ?
2. Why is paper considered eco - friendly substance?
3. Describe the steps involved in the process of paper making.
4. List any four uses of paper.
5. Paper absorbs water/oil. Why?

* * *

CHAPTER 12

CARBON AND ITS COMPOUNDS

(A) CARBON

After studying this chapter you

- recognise the compounds containing carbon used in your daily life.
- classify the given set of compounds into compounds containing carbon and compounds which do not contain carbon.
- recall the allotropes of carbon.
- define catenation.
- write the electronic configuration of excited state carbon atoms.
- arrange carbon atoms in straight chain, branched chain and ring structure.
- identify and illustrate the characteristics of carbon that make it unusual.
- make a list of several reasons why carbon (organic) chemistry deserves a chapter of its own.
- recognise the nature of chemical bond in many carbon compounds.
- define organic chemistry.
- define isomerism.

CARBON - The Chemical Basis for Life

"Carbon is a very special element because it plays an important role in the chemistry of life. Food, clothes, plastics, polymers, medicines, paper, drugs, dyes, soaps and detergents-all contain carbon compounds. Life on earth would not exist without carbon. All the compounds that make up living matter contain carbon atoms, such as carbohydrates, protein, lipids and nucleic acids. Carbon is essential to all known living systems, and without it life as we know, is impossible. It is also search for life in extra terrestrial bodies is through identifying the presence of carbon compounds."

Life itself is based upon this remarkable chemistry of carbon. Let us first know about this wonderful Element – **Carbon** and then about its **Chemistry.**

What is Carbon?

- Carbon is the first member of group 14 of the periodic table.
- It has four electrons in its outermost orbit, so its valency is four.
- Carbon is a non-metal.

Note : Graphene is an allotropic form known as metallo carbon.

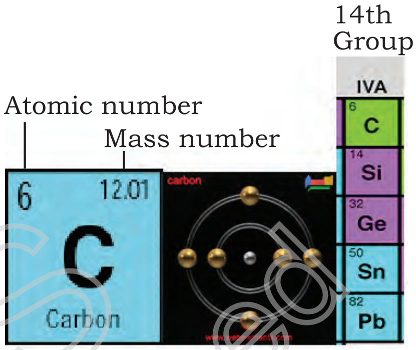


Fig 12.A(1) Position of carbon $_6C^{12}$ in the periodic table

ACTIVITY 12 A.1

1: Heat a little sugar taken in a spatula. You will observe a black residue. This shows the presence of carbon in sugar.

2: You might have observed chapati or roti getting charred when over heated, What might be the reason for this?

3: When a small quantity of milk is continuously boiled, it will get charred. But when water is boiled it will not get charred, rather it just evaporates, Why?

4: Does salt get charred when heated like sugar? Try this activity and draw your own inference.

5: When you heat sand, it does not get charred, but turns black. Why?

6: Also many substances like calcium carbonate ($CaCO_3$) which contain carbon do not get charred when heating, why? Give reasons.

Allotropes of Carbon

- In Nature, pure carbon occurs in two forms- crystalline and amorphous.
- Crystalline forms include the hardest naturally occurring substance Diamond and one of the soft substances Graphite, and artificially synthesised Fullerene and Graphene.

- *Recall the differences between diamond and graphite.*

Why are the physical properties of diamond and graphite so different?

The reason is the difference in the arrangement of carbon atoms in diamond and graphite.

What is allotrophy ?

Diamond, Graphite, Fullerene and Graphene *are the allotropes of carbon which are chemically identical and differ markedly in their physical properties. This phenomenon is called allotropy.*

Do you know

A new allotrope of carbon that was discovered in 1985, contains 60 carbon atoms C_{60}. This form has been named Buckminsterfullerene after the architect Buckminster Fuller, who designed domed structures that also resemble C_{60} molecule. (C_{60} molecules are often called buckyballs)

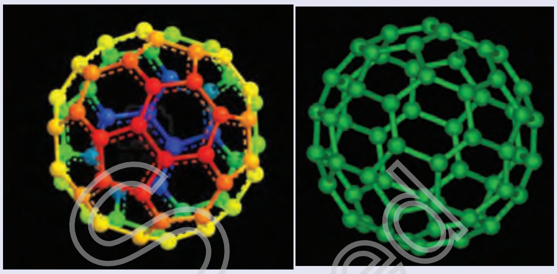


Fig 12.A(2) Fullerene

Their discoverers – Robert Curl, Harold Kroto and Richard Smalley – received the Nobel Prize in Chemistry in 1996.

Know this

The carbon can form alloys with iron, of which the most common is carbon steel. Graphite is combined with clays to form the 'lead' used in pencils used for writing and drawing. It is also used as a lubricant and a pigment, as a moulding material in glass manufacture, in electrodes for dry batteries and in electroplating and electroforming, in brushes for electric motors and as a neutron moderator in nuclear reactors .

Why is one entire branch of chemistry devoted to the behaviour of the compounds of just one element-carbon?

The answer is simple. Carbon is a unique element. It is the king of versatility. Its ability to connect with other carbon atoms through strong and stable covalent bonds sets it apart from other elements. Carbon atoms can form long chains well over 1,00,000 carbon atoms in length. In addition to forming chain, carbon atoms can link to form a multitude of unusual structures. Carbon-carbon bonds are strong, and stable. This property allows carbon to form an almost infinite number of compounds. Infact there are more known carbon-containing compounds than all the compounds of the other chemical elements combined except those of hydrogen (because almost all organic compounds contain hydrogen too).

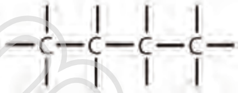
Carbon forms an exceptionally large number of compounds because of its unique characteristics like catenation, tetravalency and isomerism .

Catenation

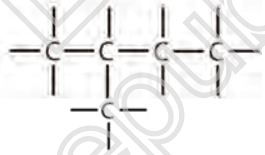
Carbon has the unique ability to form bonds with other atoms of carbon, giving rise to large molecules. This property of interconnecting C-C bonds, is called catenation("chain making"). The compounds may have a long chain of carbon, branched chain of carbon or even carbon atoms arranged in rings. Catenation is observed in the allotropes of carbon also.

This occurs in one of the following three ways:

1. Straight Chain



2. Branched Chain



3. Closed Chain

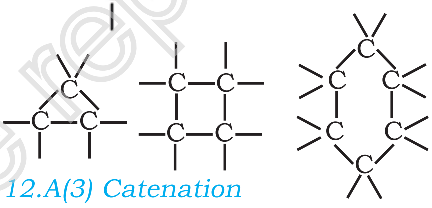


Fig 12.A(3) Catenation

Hence very large numbers of carbon compounds are possible. Infact, about ten million organic compounds are already known and a large number of new compounds are being added periodically to the domain of organic chemistry. No other element exhibits the property of catenation to an extent seen in carbon.

Do you know ?

Why aren't there millions of compounds of B, Si, Ge, Sn, N, P, O, S, Se and Te ?

Like carbon, the above elements also catenate and compound with B-B, Si-Si, Ge-Ge, Sn-Sn, N-N, P-P, O-O, S-S, Se-Se and Te-Te bonds are known. These compounds are unstable and very reactive and do not last long whereas many compounds with C-C bonds exist for centuries under ordinary conditions. The unusual stability of compounds with chains of carbon atoms is a result of the great strength of the C-C bond . The C-C bond is the second strongest single bond between like atoms after the H-H bond.

Tetravalent Character

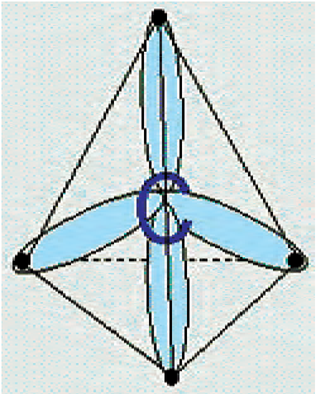
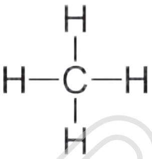


Fig. 12A(4) Structure of Methane

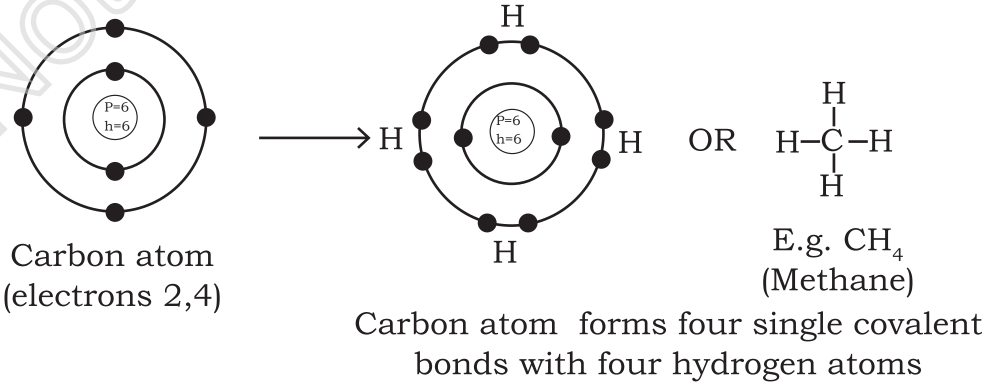


$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-H$$

Observe : Even though *the methane molecule is three dimensional with H-C-H bond angle 109^{0}28$'$by convention the methane molecule is represented in two dimension with H-C-H bond angle 90^0*

Atomic Number of Carbon	6
Electronic Configuration of Carbon (Ground state)	$1s^2$ $2s^2$ $2p_x^{\ 1}\, 2p_y^{\ 1}\, 2p_z^{\ 0}$
There are two unpaired electrons in 2nd shell	[↑↓] [↑↓] [↑][↑][ ]
Electronic Configuration of Carbon is (Excited state)	$1s^2$ $2s^1$ $2p_x^{\ 1}\, 2p_y^{\ 1}\, 2p_z^{\ 1}$
There are 4 unpaired electrons in second shell	[↑↓] [↑] [↑][↑][↑]

On excitation one electron from 2s level is promoted to 2p level. Thus there will be four unpaired electrons. Hence, **Carbon is tetravalent.**

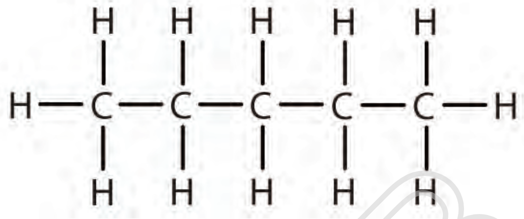


Note : The outer circle represents L shell.

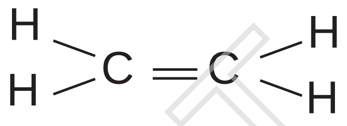
Fig. 12A(5) Tetravalency of carbon

Tetravalency of Carbon

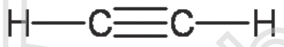
Further, the carbon atom due to its tetravalency, can be bonded to other carbon atoms by forming single, double or triple bonds. Chains of carbon atoms may be linear, branched or cyclic.



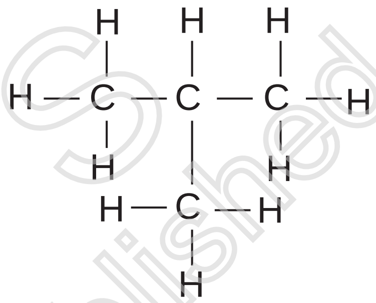
i) Linear chain



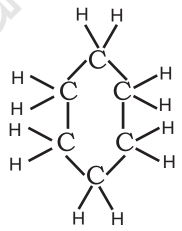
ii) Double bond



iii) Triple bond



iv) Branched structure



v) Cyclic structure

Fig 12.A(6) Tetravalency and catenation property of carbon

Carbon atom share its four electrons with other carbon atom are atoms of other elements leading to the formation of organic molecules with covalent bonds. The covalent bonds are fairly strong and stable.

1. ISOMERISM

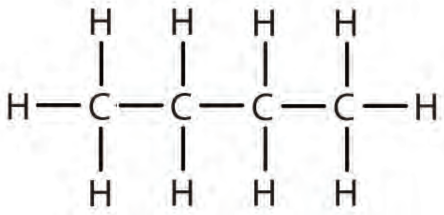


Fig 12.A(7(i)) n- butane

Observe the above structures of butane. Count the number of carbon atoms and hydrogen atoms in both the cases. You will note that both contain same number of atoms but differ in the structural arrangement. These are called isomers. This **phenomenon in which organic compounds having**

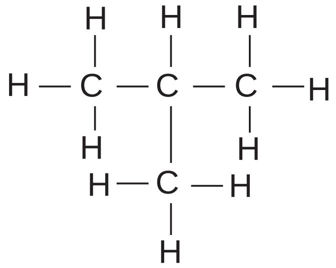


Fig 12.A(7)ii : Isobutane

same molecular formula with different structural arrangement of atoms in them is known as ISOMERISM

Isomerism increases the number of organic compounds. The more carbon atoms in a compound, the more ways of arranging the atoms and the larger number of isomers.

n-butane has its four carbon atoms bonded in a continuous chain. Isobutane has a branched structure. Isomers differ in their physical and chemical properties.

Note

The first three alkanes methane, ethane and propane do not have any isomers why?

The simplest hydrocarbons methane (CH_4), ethane (CH_3CH_3), and propane ($CH_3CH_2CH_3$) have no isomers, as there is no scope for branching of C-C chain

Try this

There are three isomers of pentane (C_5H_{12}), Try to write these isomers.

Historical Importance

The study of organic compounds as a discipline began only about 200 years ago. Till then, all chemical substances were classified on the basis of their origin, substances derived from minerals, vegetables and animals. Development in qualitative and quantitative analysis showed that all chemical substances of vegetable and animal origin contained carbon. This led Berzelius to suggest that organic compounds are derived from organisms.

Vital force theory

In 1827 Berzellius put forward the vital force theory to account for the formation of organic compounds. According to this theory, organic compounds were synthesized in living systems under the influence of a vital force. Since then vital force could not be realized artificially. It was thought that the organic compound could not be produced in the laboratory.

In 1828 Friedrich Wohler prepared urea, a typical product of animal metabolism, by heating an aqueous solution of an inorganic compound ammonium cyanate, a compound obtained from non living material.

$$NH_4Cl + AgCNO \xrightarrow{-AgCl} \underset{\substack{\text{Ammonium cyanate} \\ \text{(inorganic compound)}}}{NH_4CNO} \xrightarrow{\Delta} \underset{\substack{\text{Urea} \\ \text{(organic compound)}}}{NH_2 - CO - NH_2}$$

Until this discovery in the year 1828, it was widely believed by chemists that organic substances could only be formed under the influence of the "vital force" in the bodies of animals and plants. Wohler's synthesis dramatically proved that opinion to be false.

Fig 12.A(8)
Friedrich Wohler

Friedrich Wohler -1800– 1882 : Used inorganic substances to synthesize urea, a carbon compound found in urine.

This re-defined organic chemistry.

The synthesis of acetic acid by Kolbe and that of methane by Berthellot during the next few decades finally disproved the vital force theory. Since then thousands of organic compounds of natural origin have been synthesized.

Know this

Calcium carbide (CaC_2), Carbon monoxide (CO), Carbon dioxide (CO_2), Hydrogen cyanide (HCN) and Calcium carbonate ($CaCO_3$) are classified as inorganic substances though they contain carbon. Why? These compounds contain only one or two carbon atoms per formula unit and contain no carbon-carbon(C-C) bonds and carbon-hydrogen (C-H) bonds. Hence, they are classified as inorganic compounds.

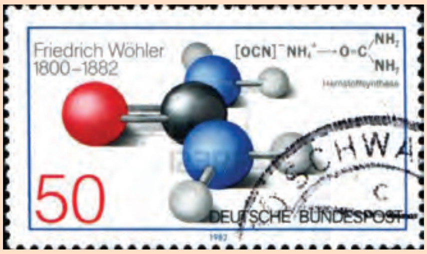


Fig 12.A(9) German stamp

This German stamp depicts molecular model of urea and was issued in 1982 to commemorate the hundredth anniversary of Wohler's death.

Wohler's experiment is now considered as a scientific milestone, the first step towards overturning the philosophy of vitalism.

A. Swedish chemist J.J. Berzelius (1779-1848) in 1801 suggested the classification of all chemical compounds into two categories as follows.:

1. Inorganic compounds 2. Organic compounds

Difference between organic and Inorganic Compounds

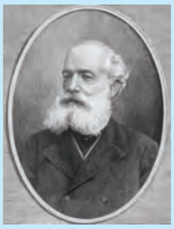
All organic compounds contain carbon. In addition they have other elements like hydrogen, oxygen, and nitrogen. A few other compounds contain sulphur, phosphorus, halogens and metals. Organic compounds show some characteristic properties. These properties distinguish them from inorganic compounds. Observe the following table.

SL. No.	Property	Organic compounds	Inorganic compounds
1.	Melting and boiling points	MP and BP low, generally volatile	MP and BP high, generally nonvolatile
2.	Nature of Bonding	Covalent bonding mainly	Ionic bonding / covalent / coordinate
3.	Solubility	Mainly insoluble in water Mainly soluble in organic solvents (e.g., alcohol)	Mainly soluble in water Mainly insoluble in organic solvents
4.	Combustibility	Almost all burn	Very few burn
5.	Nature of reaction	Slower reactions slow & molecular	Usually reactions are very fast
6.	Homology and Isomerism	Homology and isomerism common	Homology and isomerism not common

Table 12.A(1) Distinguishing properties of organic and inorganic compounds

What is Organic Chemistry ?

Carbon compounds are studied as a separate branch of chemistry, called organic chemistry. Kekulé, in 1861 said that organic chemistry is the study of compounds and reactions involving carbon, regardless of source. Eventually a new definition of organic chemistry that is the chemistry of carbon compounds of both natural and synthetic origin emerged. The misleading name "organic" has been retained for convenience and for its historical importance even after it had become clear that these compounds did not have to come from living sources but could be made in the laboratory.



DREAM has a Role in Scientific Discovery

"Let us learn to dream not of personal desire
But of Universal truth to be shared with others"

....Kekule

Fig 12.A(10) F.A. Kekule (1829-1896)

Significance of Organic Chemistry

The field of organic chemistry is probably the most active and important field of chemistry at the moment, due to its extreme applicability to both biochemistry (especially in the pharmaceutical industry) and petrochemistry (especially in the energy industry).The scope of organic chemistry is vast indeed. Organic compounds used as dyes, flavours, detergents, perfumes, cosmetics have made life more colourful and comfortable. Organic chemistry has a relatively recent history, but it will have an enormously important future, affecting the lives of everyone around the world, even biosphere, for many years to come.

Know this

How is the term " organic" used among farmers and food stores today? It is used to define something that is natural, instead of human-made or synthetic.

Exercise

I. Answer the following

1. What is allotropy?
2. Name the crystalline allotropic forms of carbon.
3. Why are carbon -based compounds lumped together as a separate subject within the study of chemistry?
4. Will carbon as an atom interact with other atoms to form ionic or covalent bonds? Explain.
5. What is the total number of electrons present in a carbon atom?
6. Write the electronic configuration of carbon atom when it is in ground state.
7. Write the excited state electronic configuration of carbon atom.
8. Define organic chemistry.
9. Write a short note on significance of chemistry.

II. Fill in the blanks

1. The usual nature of chemical bond present in organic compounds is _________ .
2. The valency of carbon atom is ___________ in spite of the presence of double are triple bond.
3. The ability of carbon atoms to link together to form short or long chain by covalent bond is called ____________ .
4. The first organic compound which was synthesized from inorganic compounds was _____________ .
5. The person who synthesized urea from ammonium cyanate was ______________ .

III. Choose the most appropriate answer from the four alternative given

1. Friedrich Wohler prepared the organic compound

a. vegetable oil	b. urea
c. sucrose	d. calcium phosphate

2. The unique property of carbon atom is

   a. forming covalent bond

   b. semiconductivity

   c. catenation, tetravalency and isomerism

   d. forming ionic bond

3. The following is an orgonic compound

   a. calcium carbide

   b. baking soda

   c. carbon dioxide

   d. citric acid

4. The organic solvent is

   a. water

   b. hydrogen peroxide

   c. hydrochloric acid

   d. carbon tetrachloride

IV. Answer the following questions

1. Distinguish between organic and inorganic compounds.
2. Make a list of five organic and five inorganic compounds used in our daily life.
3. Organic compounds are formed under some vital force. Say true or false. Explain.
4. Name three typical organic compounds commonly present in our food.
5. Describe catenation by giving suitable examples.
6. Why was vital force theory rejected?
7. What is isomerism? Give an example.

V. Match the following

A	B
1. Compounds containing carbon	a. Urea
2. First synthesized organic compound	b. Ammonium cyanate
3. A property of carbon atom	c. Organic compound
	d. Catenation

* * *

(B) HYDROCARBONS

After studying this chapter you

- give examples for fossil fuel containing hydrocarbons.
- classify the given set of hydrocarbons into aliphatic and aromatic hydrocarbons.
- classify the given set of aliphatic compound into alkanes, alkenes and alkynes.
- distingush between saturated and unsaturated hydrocarbons.
- represent arrangement of carbon atoms in straight chain, branched chain & ring structure.
- give examples for aromatic hydrocarbons.
- use IUPAC system to name the hydrocarbons.
- draw the structures of given hydrocarbons.
- name the substitution products of methane.
- write the molecular formulae of aliphatic hydrocarbons using the general formulae.
- know the uses of aromatic hydrocarbons.
- define homologous series.
- you are able to differentiate between alkanes, alkenes & alkynes.

If you look around your house, you will encounter all these hydrocarbon products in your everyday routine. Substances like naphthalene -a moth repellent, wax used in making candles and fuels like LPG, kerosene and petrol.

Cooking oils, Cleaning products-Cleaners (such as: wood oil, metal, adhesive and pine), spot remover and liquid furniture polish. Cosmetics - baby, hair and bath oils; sunscreen, nail enamel dryers and makeup removers, plastic bags and thermocoles are derived hydrocarbon compounds.

Do you know?

The orange colour of carrots, the yellow colour of butter and yolk of egg, the red colour of tomatoes, the wax coating on apples which increases the shelf life of apples and the cooking gas are all Hydrocarbons.

Fig 12B (1) Hydrocarbon compounds in the Kitchen

Activity 12 B.1

Make a list of hydrocarbon products used in your daily life.

So what are these Hydrocarbons?

Hydrocarbons are the binary organic compounds containing carbon and hydrogen only.

These are widely distributed in nature in the form of petroleum, natural gas and coal. Hydrocarbons are the parent organic compounds and all other organic compounds are thought to have been derived from these hydrocarbons by replacing one or more hydrogen atoms by a suitable **functional group**.

Hydrocarbons can be gases (e.g. methane and propane), liquids (e.g hexane and benzene), waxes or low melting solids (e.g. paraffin wax and naphthalene) or polymers (e.g. polyethylene, polypropylene and polystyrene). Hydrocarbons are economically important because, major fossil fuels such as coal, petroleum and natural gas, and its derivatives such as plastics, paraffin, waxes, solvents and oils are hydrocarbons.

Know this

Hydrocarbons react with oxides of nitrogen, in presence of sun light and produce photo chemical smog.

Activity 12 B.2

Take a candle and observe the smell by holding it near your nose.

Now light the candle and find out whether the smell is there.

Lastly put out the candle and notice the smell.

You will wonder to know that the smell is found only when the candle is put out, not in the previous cases. It clearly indicates that the wax of the candle which is hydrocarbon has no smell either in the solid or in the liquid state but has characteristic odour ***only in vapour state. Hydrocarbons usually do not have any characteristic odour but some higher hydrocarbons in their vapour state have characteristic smell.***

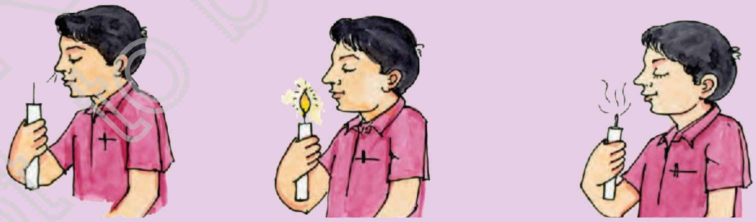


Fig 12 B (2) Higher hydrocarbons have characteristic odour in vapour state.

Hydrocarbons are currently the main source of the world's electric energy and heat sources because of the energy produced when burnt. Often this energy is used directly as heat, such as in home heaters, which use either oil or natural gas. They are used as the starting materials for the manufacture of many dyes and drugs.

In their solid form, hydrocarbons take the form of asphalt. Mixtures of volatile hydrocarbons are now used in preference to the chlorofluorocarbons as a propellant for aerosol sprays, due to chlorofluorocarbon's impact on the ozone layer.

Sources of Hydrocarbons

Petroleum and coal are the two principal sources of hydrocarbons. Aliphatic hydrocarbons are mainly obtained by petroleum whereas aromatic hydrocarbons are mainly obtained from coal. Ozokerite (a natural wax) and waxes of some plants also contain some higher alkanes.

Classification

Based on structure, hydrocarbons are classified into two main groups.

1) Open chain or acyclic compounds.

2) Closed chain or cyclic (or ring) compounds.

Aliphatic Hydrocarbons are also called acyclic or open chain hydrocarbons. These hydrocarbons consist of straight or branched chains of carbon atoms.

Know this

(Greek work- aliphatos means fat. Hence the open chain acyclic hydrocarbons are called aliphatic hydrocarbons.)

There are millions of organic compounds. It is physically impossible to study each individual compound. To facilitate their study, these organic compounds are classified into various groups and sub-groups.

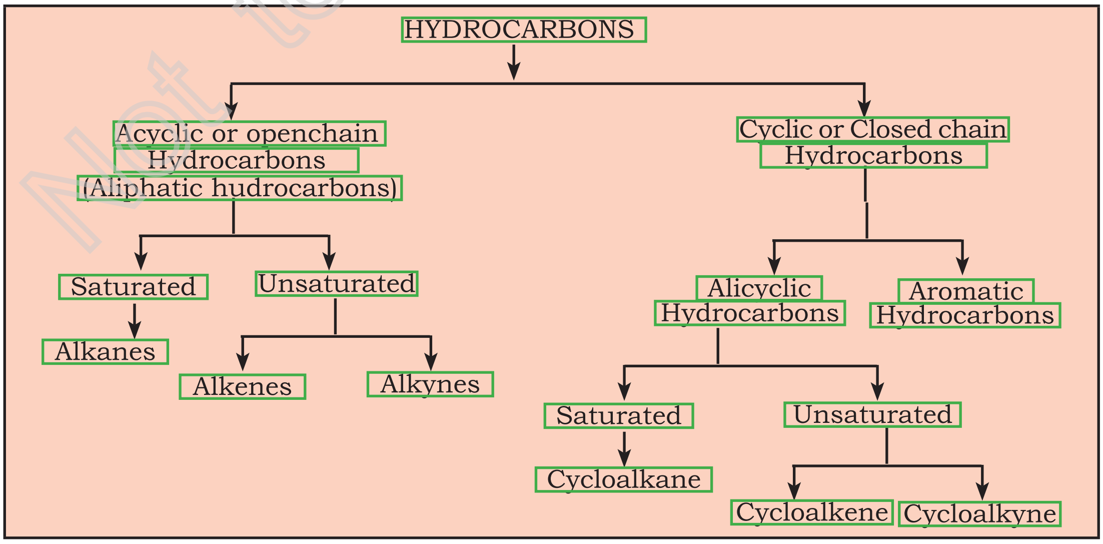


Fig 12 B (3) Classification of hydrocarbons

Aliphatic hydrocarbons

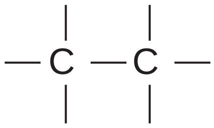
Are further classified into two main types, saturated (alkanes) and unsaturated (alkenes and alkynes)depending on the presence or absence of C-C single, double or triple bonds.

Saturated Hydrocarbon

C_nH_{2n+2}

An alkane

(with single bond only)



$$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$$

Unsaturated Hydrocarbon

C_nH_{2n}

An alkene

(with atleast one double bond)

$>C=C<$

C_nH_{2n-2}

An alkyne

(with atleast one triple bond)

$-C\equiv C-$

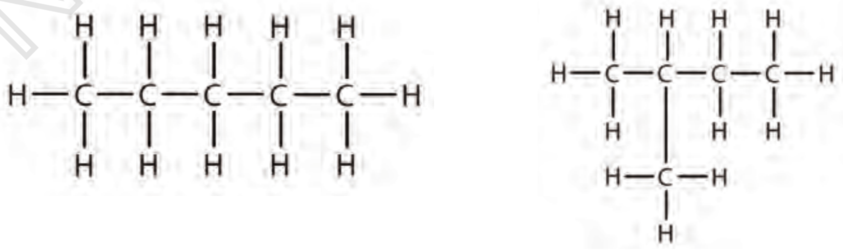
Saturated Hydrocarbons : Saturated hydrocarbons (alkanes) are the simplest of the hydrocarbon species and are composed entirely of single bonds between carbon atoms. In this type of compound, the carbon atoms are arranged in chain-straight or branched.

Know this

Saturated hydrocarbons do not react with hydrogen while alkenes and alkynes react to form alkanes.

In these hydrocarbons all carbon atoms are bonded to the maximum number of hydrogen atoms. They are composed entirely of single bonds between carbon atoms and are saturated with hydrogen i.e, every bond is used. They are also known as Paraffins.

Example



n-pentane
a. Straight chain

iso-pentane
b. Branched chain

Fig 12 B (4)

Know this

Paraffin which is derived from a Latin word meaning 'less activity' and means that compounds undergo a very few reactions. (no affinity for water)

The first five members of the series are

Name	Methane	Ethane	Propane	Butane	pentane
number of C (n)	1	2	3	4	5
number of H(2n+2)	4	6	8	10	12
Molecular formula	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}

Table 12 B (1) Homologous series (Alkanes)

You might have noticed a relationship between the amount of carbon and the amount of hydrogen in each alkane molecule.

Number of hydrogen atoms = (2 × number of C atoms)+2

Therefore this class of compound (Alkanes) is represented by a general molecular formula C_nH_{2n+2} where 'n' stands for the number of carbon atoms.

For example;

Hexane has six carbon atoms, so n=6

Number of hydrogen atoms = $2n+2 = (2\times6)+2 = 14$

So the molecular formula for hexane is $\mathbf{C_6H_{14}}$.

The alkanes are a homologous series of hydrocarbons derived from CH_4 by inserting - ' CH_2' groups.

Nomenclature of Alkanes

The table below gives the name for continuous chain alkanes upto 10 carbon atoms in length. The compound's name end in 'ane', signifying that the compounds are alkanes, each stem or root is derived from the Greek or Latin name for the number of carbon atoms in the molecule. An infinite number of alkanes can be made simply by lengthening the chain 100 or 1000 or 1 million.

They are named systematically, with a prefix or word root indicating the number of carbon atoms per molecule, and the ending “ane” (suffix).

Prefix is determined by the number of carbon atoms in the chain.

Prefix or word root	Number of Carbon atoms
Meth-	1
Eth-	2
Prop-	3
But-	4
Pent-	5
Hex-	6
Hept-	7
Oct-	8
Non-	9
Dec-	10

Table 12 B (2) Word roots or prefixes

First four prefixes

Meth- Monkeys

Eth- Eat

Prop- Peeled

But- Bananas

Fig 12 B (5) Mnemonic for first four prefixes

Activity 12 B.3

- *Follow the table 12B (2) given above and write the structural formulae for the other six alkanes, containing carbon atoms 5 to 10. Use the formula C_nH_{2n+2}.*
- *Using paper balls, clay balls and toothpicks, construct the structures of following hydrocarbons.*

  1. Methane 2. Ethane 3. Butane 4. Hexane 5. Heptane
- *Take two methane molecules already prepared. Construct ethane molecule.*
- *Tabulate the changes that you made.*

In order to derive the IUPAC name, a suffix is added to the word root which indicates saturation or unsaturation in the molecule. The suffixes, thus used are called primary suffixes. The primary suffixes are given below

Class of Compound	Primary Suffix	General Name
Saturated $-\overset{\vert}{\underset{\vert}{C}}-\overset{\vert}{\underset{\vert}{C}}-$	-ane	Alkane
Unsaturated (>C=C<)	-ene	Alkene
Unsaturated(-C=C-)	-yne	Alkyne

Table 12 B (3) Prymary suffixes of aliphatic hydrocarbons

Methane (CH_4) 'Marsh gas'

Fig 12B (6) Production of methane gas

Methane is found in the natural gas from oil wells. It is also a constituent of the coal gas. It is formed in the marshy places by the bacterial decomposition of the vegetable matter and hence called **Marsh gas**.

Methane is the first member of the alkanes or the saturated hydrocarbons, in which each carbon is bonded to four other atoms through single covalent bonds. Hydrogen atoms usually occupy all available bonding positions after the carbon have bonded to each other.

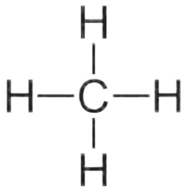


Fig 12 B (7a)
Structure of Methane

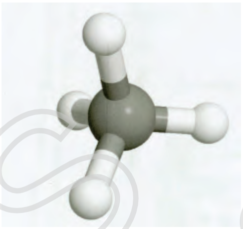


Fig 12 B (7b) Ball and stick model

Preparation of Methane Laboratory Method

By heating fused sodium acetate with soda lime: A mixture of sodium acetate and soda lime (NaOH + CaO) is heated in a hard glass test tube and methane gas is evolved. It is collected by the downward displacement of water.

$$CH_3COONa + NaOH \xrightarrow{CaO} Na_2CO_3 + CH_4 \uparrow$$

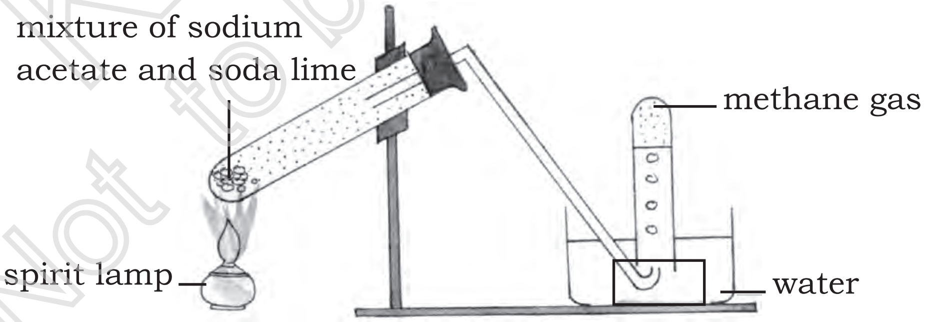


Fig 12B (8) Preparation of Methane

Think

Methane gas is collected by the downward displacement of water Why?

Physical Properties

Methane is a colourless, odourless gas, lighter than air. It is slightly soluble in water and fairly soluble in organic solvents like alcohol and ether.

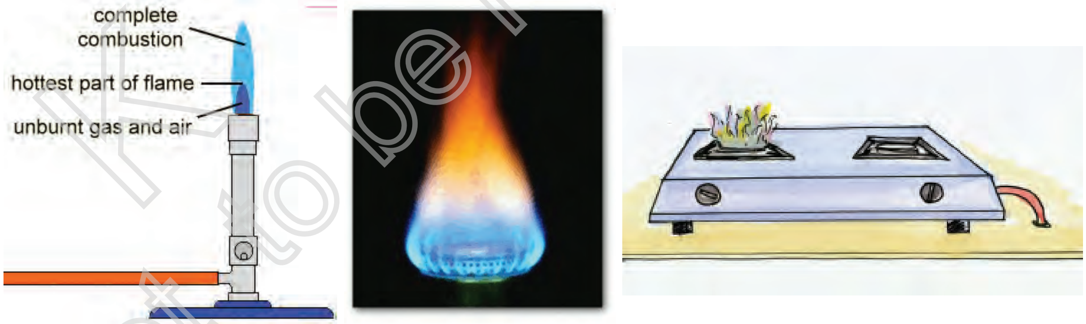
Chemical Properties

Methane being saturated, is chemically inert. It is not attacked by acids, alkalies and oxidizing agents like conc sulphuric acid, nitric acid and potassium paramanganate.

Combustibility

1. Complete Combustion : During complete combustion, methane burns in air or oxygen with a blue flame, forming carbon dioxide and water.

$$CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (l)$$



a. Bunsen burner b. Gas flame c. Gas stove

Fig 12B (9) Combustion

2. Incomplete Combustion : During incomplete combustion, methane gas burns with a yellow flame (unlike the clear blue flame seen in complete combustion). Carbon particles (sooty marks) may also be seen.

Methane + Oxygen ⟶ Carbon monoxide + Water.

$$2CH_4(g) + 3O_2(g) \longrightarrow 2CO(g) + 4H_2O(l)$$

Do you know

What is carbon monoxide?

Carbon monoxide is a very poisonous gas. It can not be seen or smelt. Faulty gas fires or boilers may produce carbon monoxide and poison the air in a room without anyone knowing. Every year, people die from carbon monoxide poisoning.

Why is carbon monoxide poisonous?

Carbon monoxide acts as a poison by combining with haemoglobin in the blood. Haemoglobin normally reacts with oxygen of the air and transports the oxygen to the parts of the body which need it. Carbon monoxide is much more reactive with haemoglobin than oxygen is. It combines to form carboxy haemoglobin a stable compound with haemoglobin, preventing the transport of oxygen around the body. The person dies of suffocation from inside.

Fig 12B(10) : Automobile exhaust emitting carbon monoxide.

Substitution Reaction: When a mixture of methane and chlorine is exposed to ultraviolet light - typically sunlight - a substitution reaction occurs and the organic product chloromethane is formed.

$$CH_4 + Cl_2 \xrightarrow{uv} CH_3Cl + HCl$$

However, the reaction doesn't stop there, and all the hydrogens in the methane can in turn be replaced by chlorine atoms to produce substitution products like chloromethane, dichloromethane, trichloromethane (chloroform) and tetrachloromethane (carbon tetrachloride).

$$CH_4 + Cl_2 \xrightarrow{uv} CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \xrightarrow{uv} CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow{uv} CHCl_3 + HCl$$

$$CHCl_3 + Cl_2 \xrightarrow{uv} CCl_4 + HCl$$

Homologous Series

A homologous series is a family of organic compounds with the same general formula, similar chemical properties, and successive members differing by -CH_2.

A set of hydrocarbons with a group name like the alkanes, alkenes and alkynes are three different homologous series of aliphatic hydrocarbons.

The following are characteristics of members of a homologous series.

1. They have properties that vary in a regular and predictable manner
2. They have similar chemical properties.
3. They have gradually varying physical properties
4. Their formulae fit the general molecular formula.
5. Adjacent members CH_4 and C_2H_6 or C_5H_{12} and C_6H_{14} differ by one carbon and two hydrogens.

Eg :

(1)
$$\begin{array}{rl} CH_4 & \text{Methane} \\ +\ CH_2 & \\ \hline C_2H_6 & \text{Ethane} \end{array}$$

(2)
$$\begin{array}{rl} C_5H_{12} & \text{Pentane} \\ +\ CH_2 & \\ \hline C_6H_{14} & \text{Hexane} \end{array}$$

Alkanes have general formula as C_nH_{2n+2}. Therefore they are homologues. Verify the formula.

Activity 12 B. 4

Complete the table below

Name	Carbon Atoms	Hydrogen Atoms	Number of bonds	Chemical formula
Methane	1	4	4	CH_4
Ethane	2	6	7	C_2H_6
Propane	3			
Butane	4			
Pentane	5			

Unsaturated hydrocarbons

Have one or more double or triple bonds between two successive carbon atoms somewhere in the chain.

Alkenes : Alkenes are unsaturated hydrocarbons that contain double bond between two carbon atoms. Alkenes are also called Olefins. The general molecular formula of alkenes is C_nH_{2n} (assuming non-cyclic structures).

In these compounds two hydrogen atoms are less when compared with the corresponding saturated hydrocarbons (alkanes). The two of the carbon atoms in the molecule joined together by two covalent bonds. This is called a double bond.

The simplest alkene has two carbon atoms with double bond between them, and is called **ethene**. Observe the structure.

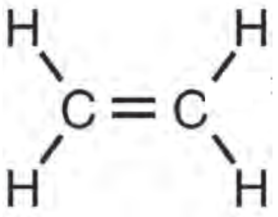


Fig 12B(11)
Ethene (C_2H_4)

Activity 12 B. 5

Take the ethane model you prepared. Re organize this molecule into ethene and answer the following questions.

- *What is the molecule formula of this new compound?*
- *Is this still an organic hydrocarbon?*
- *What have you done to the ethane molecule?*
- *If the molecule formula for the compound has changed, is it still ethane?*

Naming Alkenes

The first member of the alkene series is ethene or ethylene. The -ene suffix indicates a double bond, whereas the -ane suffix indicates a single bond.

Observe the following examples.

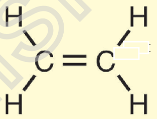
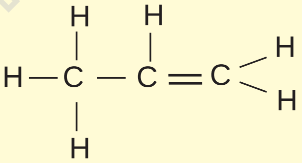
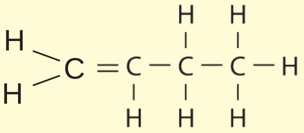
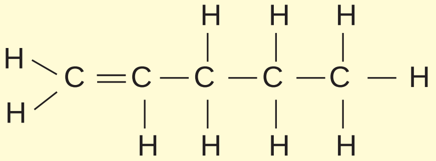
Name	No. C atoms (n)	No. H atoms (2 × n)	Moleculer Formula	Structural formula
ethene	2	2 x 2 = 4	C_2H_4	
propene	3	2 x 3 = 6	C_3H_6	
butene	4	2 x 4 = 8	C_4H_8	
pentene	5	2 x 5 = 10	C_5H_{10}	

Table 12B(4) Alkenes with their structures

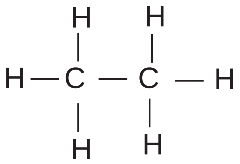
The above mentioned alkenes are also a homologous series, for you can notice that the formula of one alkene differs from that of the preceding alkene by a CH_2 group.

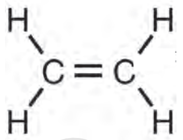
Activity 12 B. 6

- Follow the examples given above and write the structural formulae of (i) hexene (ii) heptne and (iii) octene

NCERT
Not to be republished

Compare the structure of ethene with that of ethane.





* Each carbon atom forms four bonds, each carbon in ethene is joined to two hydrogen atoms, and the other two are attached to adjacent carbon atoms through two covalent bonds (double bonds) but in alkane each carbon is joined to three hydrogen atoms, and the other bond is attached to the successive carbon atom.

- ethene is said to be unsaturated because each molecule does have carbon -to-carbon double bond and has less maximum possible number of hydrogen atoms. Ethane is said to be saturated since each molecule has no carbon-to-carbon double bond and has the maximum possible number of hydrogen atoms.

Alkynes

Unsaturated hydrocarbons that contain one triple bond between carbon atoms are called **alkynes.**

Alkynes are a homologous series of hydrocarbons with the general formula C_nH_{2n-2}.

Naming Alkynes : The IUPAC nomenclature for alkynes is similar to that for alkenes except that the suffix -yne is used to indicate a triple bond in the chain.

- Ethyne (C_2H_2) is the first member of the series, commonly called acetylene.

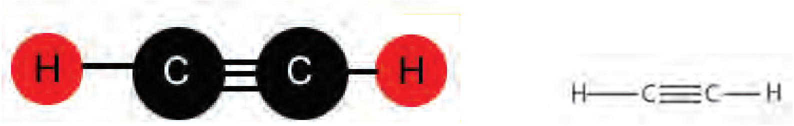


Fig 12B (12) Structure of Ethyne (acetylene)

Know this

IUPAC: International Union of Pure and Applied Chemistry

Observe the following table.

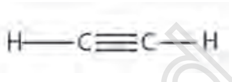
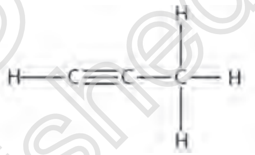
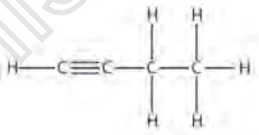
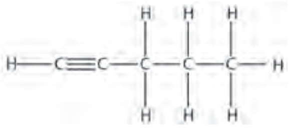
Name	**No. C atoms (n)**	**No. H atoms (2xn)-2**	**Molecular Formula**	**Structural formula**
ethyne	2	(2 x 2)-2 = 2	C_2H_2	
propyne	3	(2 x 3)-2 = 4	C_3H_4	
butyne	4	(2 x 4)-2 = 6	C_4H_6	
pentyne	5	(2 x 5)-2 = 8	C_5H_8	

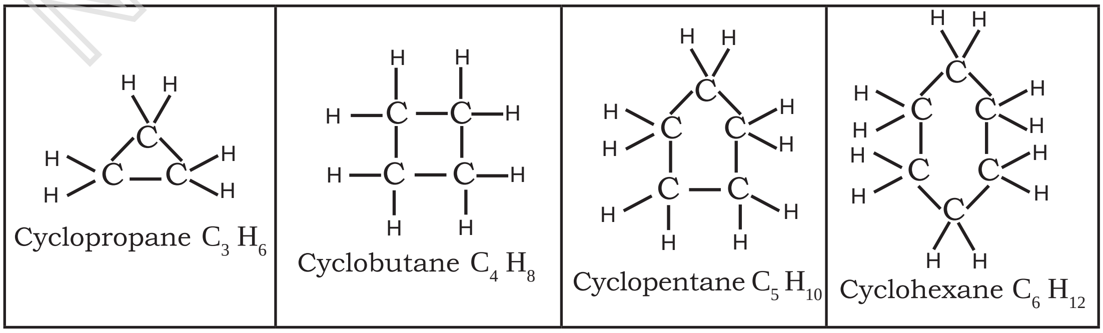
Table 12 B (5) Alkynes and their structures

The above mentioned alkynes are also a homologous series for you can notice that the formula of one alkyne differs from that of the proceeding alkyne by a- 'CH_2' group.

Cycloalkanes

Cycloalkanes are closed chain saturated hydrocarbons the general formula for a saturated hydrocarbon containing one ring is C_nH_{2n}.

Examples



Cyclopropane C_3H_6

Cyclobutane C_4H_8

Cyclopentane C_5H_{10}

Cyclohexane C_6H_{12}

Fig12 B (13) Examples for Cycloalkanes

Think

Alkenes and cycloalkanes have the same general formula they are not homologues. Why ?

Aromatic hydrocarbons

Aromatic hydrocarbons (also known as arenes) are hydrocarbons that have at least one aromatic ring (benzene type ring). The simplest member is benzene ($\mathbf{C_6H_6}$).

Structure of Benzene: The benzene ring is one of the most important structures in organic chemistry. It is a ring of six carbon atoms with alternate single and double bonds. In reality, these bonds are "spread around" the ring so that the molecule is symmetrical. In practice the structure of benzene is represented by hexagon with a circle.

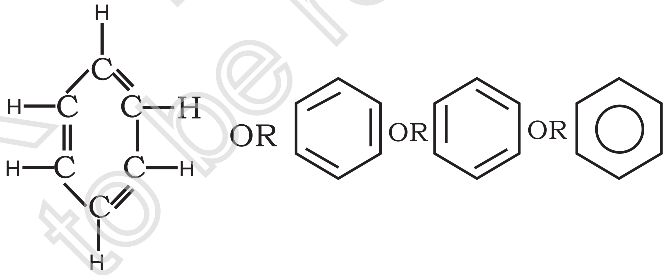


Fig 12B (14) Benzene Structure

Know this

Kekule, Friedrich August (1829-96) German Chemist.

Kekule proposed ring structure for benzene. This was done as a result of his dreaming of a serpent catching its own tail.

Other Aromatic Hydrocarbons

Examples:

1) Toluene this molecule can be depicted as:

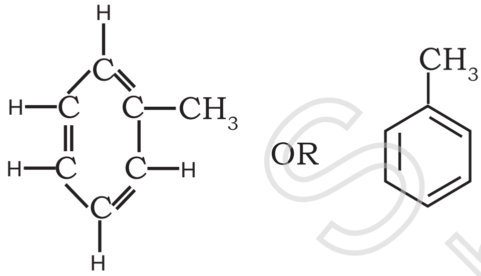


Fig 12B (15) Toluene $C_6H_5CH_3$

2) Naphthalene –This can be depicted as two fused Benzene Rings.

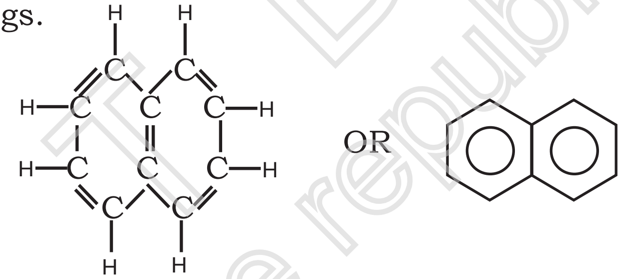


Fig 12B (16) Naphthalene $C_{10}H_8$

Note

The name AROMA is a misnomer in the case of Aromatic Hydrocarbons. Aroma means an attractive flavour but surprisingly aromatic hydrocarbons do not have any odour or some have nauseating odour.

Eg; Naphthalene - smell of moth ball. Benzene and Toluene - smell of Kerosene and so on. Camphor - having good smell but does not contain aromatic ring !

Uses of Aromatic Compounds

1. Benzene is used

1) as a solvent for oils, fats, resins, rubber, sulphur, iodine etc.
2) in the manufacture of dyes, drugs, perfumes, explosives etc.
3) in the preparation of gammexane, an insecticide.
4) for drycleaning.

2. Toluene is used

1) as a solvent for oils, fats, paints, lacquers, resins, etc.
2) in the manufacture of Trinitrotoluene (TNT) (an explosive)

3. Napthalene is used

1) as an insecticide in the form of moth balls.
2) in the synthesis of dyes.

Know this

What is the valency of carbon atom in the molecules of ethane, ethene and ethyne?

The valency is four. In all these three compounds all the four valence electrons of carbon atom take part in the formation of covalent bond. Depending upon the pairs of electrons shared between carbon atoms, single, bond, double bond, triple bond are formed.

Exercise

I. Classify the following into saturated and unsaturated hydrocarbons.

1. benzene, cyclopropane, alkene, alkane.
2. Classify the compounds containing double bond and triple bond. ethyne, benzene, butyne, pentene.

II. Give reasons for the following

1. Alkanes are chemically stable.
2. Alkanes undergo only substitution reactions but alkenes and alkynes undergo both substitution and addition reactions. Why?

III. Answer the following

1. What is a homologous series? Give an example of such series.
2. Define isomerism. Give examples.
3. Write the structures of following

   1. Isobutane   2. Benzene   3. Cyclohexane
   4. Ethene   5. Propyne

4. Mention the uses of benzene.
5. What does IUPAC represent?
6. Draw the formulae of the first four members of each homologous series beginning with the following compounds.

   1. $HC\equiv CH$ 2. $H_2C=CH_2$

IV. Choose the correct answer from the four alternatives given below

1. When three hydrogen atoms of methane molecule are substituted by three chlorine atoms, we get

   a. DDT   b. Chloroform

   c. Methyl alcohol   d. CFC (chloroflurocarbons)

2. The molecular formula of an alkane containing five carbon atoms is

   a. C_5H_8 b. C_5H_{10}

   c. C_5H_5 d. C_5H_{12}

3. The following hydrocarbon contains three double bonds

   a. ethane   b. ethene

   c. benzene   d. cyclohexane

4. The number of hydrogen atoms to be added to benzene to make it cyclohexane is

a. two b. three

c. four d. six

5. In ethane, each carbon is bonded to

a. Six atoms b. Three atoms

c. two atoms d. four atoms

6. General formula for an alkyne is

a. C_nH_{2n} b. C_nH_{2n-2}

c. C_nH_{2n+2} d. C_nH_{2n+1}

V. Match the following.

	A	B
a.	aromatic hydrocarbons	i) pentane
b.	alicyclic hydrocarbons	ii) isobutane
c.	alkenes	iii) cyclopropane
		iv) toluene
		v) ethene

(C) FUNCTIONAL GROUPS

After studying this chapter you

- define functional group and poly functional group compounds.
- distinguish various functional groups.
- draw the structure of glycerol and salicylic acid.
- generalise the IUPAC nomenclature of organic compounds.

Hydrocarbons are the parent organic compounds and all other organic compounds are regarded as derivative of these hydrocarbons. In which one or more hydrogen atoms has been replaced by an atom (or a group of atoms) of other elements called functional group.

Organic compounds such as

Methyl alcohol (methanol) molecular formula - CH_3OH

Ethyl alcohol (Ethanol) molecular formula - C_2H_5OH.

Propyl alcohol (Propanol) molecular formula - C_3H_7OH

and many other alcohols undergo similar kinds of reaction. What is common in all these three and many other alcohols? Why do all react with acetic acid and form a class of compounds called esters? This may be because each alcohol contains the –OH group as its functional group. It is the –OH group that reacts with acetic acid. So the characteristic chemical reactions of this class of compounds 'ALCOHOLS' depend on these **'group of atoms –OH'** which are called functional groups.

So "Functional groups are the sites where major reactions occur in organic molecules". **Functional groups are -specific groups of atoms or bonds within molecules that are responsible for the characteristic chemical reactions of those molecules**. The functional group is helpful in prediction of the properties of the molecule.

Compounds that contain the same functional group react in a similar manner and are said to form a class or family. On the basis of the functional group present, organic compounds are classified into distinct classes.

Each class of organic compounds is made up of two parts

An alkyl/aryl radical
[**R**] (Hydrocarbon part)
relatively less reactive

Functional group(Active part)[**X**]
1) Site of a chemical reaction
2) Responsible for the
characteristic properties

Thus each class may be represented by the general formula R-X

R (alkyl/aryl radical) + **X** (Functional group) = A class of organic compounds.

Compounds containing -OH as the functional group are said to form a class called **Alcohols**. They are represented by the general formula R-OH. Benzene ring structures with -OH group are called **Phenolic compounds**.

Compounds containing -COOH as the functional group are said to form a class called **Carboxylic acids**. They are represented by the general formula R-COOH

Compounds containing -CHO as functional group are said to form a class called **Aldehydes**. They are represented by the general formula R-CHO.

Compounds containing $-NH_2$ as functional group are said to form a class called **Amines**. They are represented the general formula $R-NH_2$.

Know this

R - methyl, ethyl, propyl and so on are alkyl groups

R^1 -compounds containing Benzene rings are aryl groups

IUPAC Nomenclature of class of Organic Compounds

Alcohols

Alcohols are the derivatives of hydrocarbons in which an -OH group has replaced a hydrogen atom. Though all alcohols have one or more hydroxyl (-OH) functional group, they do not behave like bases, such as NaOH and KOH. Those strong bases are ionic compounds that contain OH^- ions. Alcohols are covalent molecules, the -OH group attached to a carbon atom is by a covalent bond.

A three carbon alcohol is named as: $CH_3CH_2CH_2$-OH = propanol
The name is derived as follows:
Three carbon root name = propane.
Drop the "e" ending and add "ol" the ending for alcohol.
Thus the name = propan + ol = propanol.

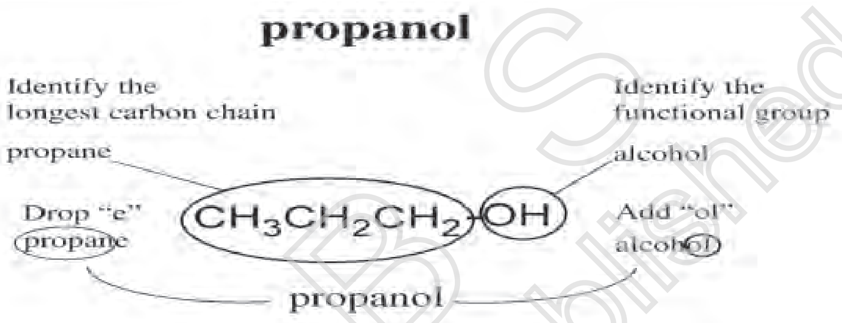


Fig 12C (1) Nomenclature of propanol

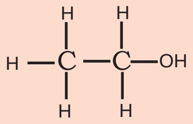
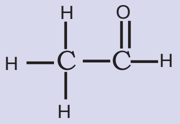
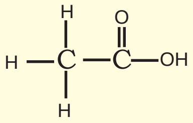
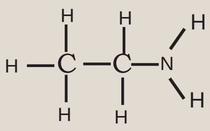
Group of organic compounds	*General Formula*	*Functional Group*	*Suffix*	*IUPAC name of family (word root + suffix)*	*Example*
ALCOHOLS	R -OH	-OH	-ol	Alkan**ol**	 Ethanol (C_2H_5OH)
ALDEHYDES	R -CHO	$-\overset{O}{\overset{\|}{C}}-H$	-al	Alkan**al**	 Ethanal (CH_3CHO)
CARBOXYLIC ACID	R -COOH	$-\overset{O}{\overset{\|}{C}}-OH$	-oic acid	Alkan**oic acid**	 Ethanoic acid (CH_3COOH)
AMINES	R -NH2	$-\overset{H}{\overset{\|}{N}}-H$	-amine	Alkyl**amine**	 Ethamamine

Table 12C (1) Method of naming of organic compounds

Activity 12 C.1

Write the molecular formulae, names and structures of first five members of above mentioned class of compounds

Poly functional compounds

In the previous classes you have studied that protein is an important constituent of food. Proteins are chains of amino acids and its simplest form is amino acid. Our body needs 20 types of amino acids.

An amino acid is any molecule that contains both amino (-NH_2)and carboxylic acid (-COOH) functional groups. The simplest, and smallest, amino acid found in protein is glycine

$$H_2N\text{-}CH_2\text{-}COOH$$

Glycine

Organic compounds having more than one functional group are called polyfunctional compounds.

Functional groups may be same or different.

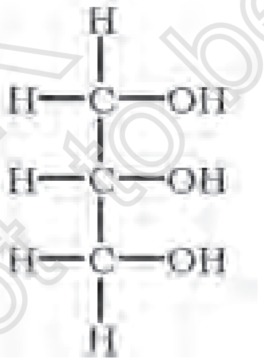


Fig.12C(2)a. Structure of Glycerol

Functional groups are same

(all three are same -OH group)

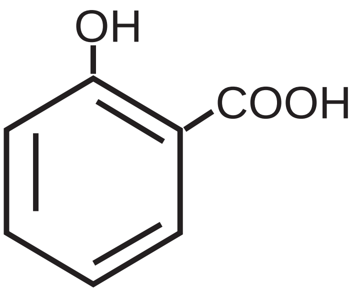


Fig.12C(2)b. Salicylic Acid

Functional groups are different

(one, -OH group the other one, -COOH group)

Know this

Glycerol, which is a byproduct of soap industry, contains three hydroxyl groups. It is a trihydric alcohol.

Salicylic acid which is used in the production of aspirin contains one –OH group and one – COOH group.

Know this

Molecular formula of Sodium hydroxide is NaOH-(contains one hydroxyl ion).

Molecular formula of Ammonium hydroxide is NH_4OH --- one hydroxyl ion.

Molecular formula of Calcium Hydroxide is $Ca(OH)_2$ --- two hydroxyl ions.

In all the above examples, hydroxyl ions (OH^- ions) are common, number may change but hydroxyl ions present in the above compounds give the properties of a base to the compound in which they are present.

How many hydroxyl ions are there in Aluminium hydroxide $Al(OH)_3$?

You have come across alcohols like Methyl alcohol- molecular formula CH_3OH and Ethyl alcohol- molecular formula C_2H_5OH in your previous classes.

Though these compounds contain hydroxyl group they are not called hydroxides but called alcohols. Why?

CH_3OH is not called methyl hydroxide but called methyl alcohol

On the other hand compounds containing hydroxide ions are not called alcohols but called hydroxides.

NaOH is not called sodium alcohol but called Sodium hydroxide

So how are these hydroxyl ions and hydroxyl groups different from one another?

In the case of organic compounds like alcohols hydroxyl group is just a group of atoms -OH which is cavalently bonded to a carbon atom. The -OH is a functional group occurs in several classes of organic compounds including alcohols, phenols and carboxylic acids. You should not confuse it with the hydroxide ion, OH^- of inorganic hydroxides which is a diatomic ion.

Exercise

I. Answer the following.

1. Explain functional group with examples.
2. Write general formulae of organic compounds that you studied.
3. Draw the structure of a) glycerol b) salicylic acid
4. Ethanol cannot be called poly functional compound. Why?
5. Though sodium hydroxide has hydroxyl group, it can not be called sodium alcohol.
6. Explain the naming criteria of organic compounds with an example.
7. Why is glycine is considered as poly functional compound?

II. Fill in the blanks with the suitable answers.

1. Functional group present in methanamine is ____________ .
2. Site of chemical reaction in an organic compound is ____________ .
3. In R-X less reactive part is ____________ .

(D) HYDROGENATION OF OILS

After studying this chapter you

- you distinguish oils from fats .
- define saponification value.
- reason for hydrogenation of oils.

Activity 12 D.1

Take 5 used medicine bottles and clean them thoroughly. Allow them to dry. In each of the bottle take one spoon of molten Vanaspathi, coconut oil, palm oil, groundnut oil and sunflower oil, separately and label them. Add few drops of water to each of the bottle. Keep the bottles exposed to air and sunlight for about a week. Smell the bottles. In which of the bottle can you get the **foul smell of rancid** *Fat or Oil more?*

Earlier you have studied that alkanes are hydrocarbons which are saturated. They are chemically stable. However alkenes and alkynes are unsaturated and chemically reactive. Long chain alkanes or alkenes if contain a terminal carboxylic acid group [-COOH.], are called fatty acids. If these fatty acids react with trihydric alcohol called glycerol to form ester called glycerides. Glycerides are referred to as fat or oil. Remember that glycerol is also a polyfunctional compound containing three hydroxyl groups [-OH].

$$\text{Fatty acid + Glycerol} \xrightarrow{\text{esterification}} \text{Fat/oil + water}$$

Fats and oils (Triglycerides) are esters of fatty acids and glycerol (IUPAC name is 1,2,3- propantriol). Since glycerol has three alcohol(-OH) functional groups, three fatty acids must react to make three ester functional groups. The three fatty acids may or may not be identical.

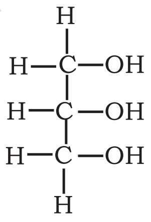


Fig 12D (1)a

Glycerol

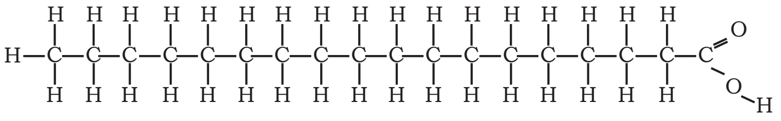


Fig 12D (1)b Stearic acid ($C_{17}H_{35}COOH$) is an example of a saturated fatty acid, since there are no double bonds in its carbon chain.

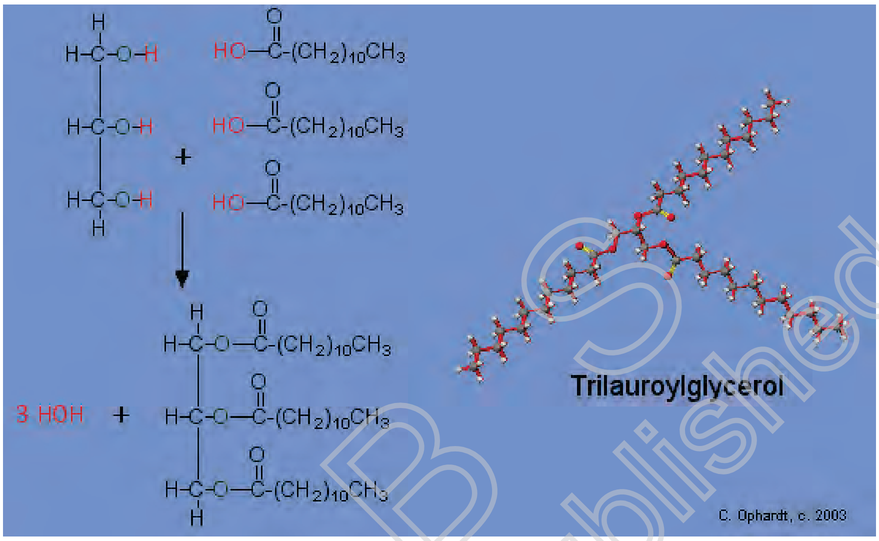


Fig 12D(2) Triglyceride - Ester synthesis

How are fats different from oils?

There is no much difference in chemical properties between them. but they differ in physical properties. Oils are mostly unsaturated and usually liquids at room temperature. Fats are mostly saturated and solids at room temperature.

Unsaturated oils are easy to digest because they are chemically reactive. Many health conscious people consume food cooked in unsaturated oils like sunflower oils. Saturated oils are digested slowly because they are chemically more inactive. Unsaturated oils have very little **shelf life** because they undergo oxidation in air and produce a foul smell. In other words the oils become rancid. Oils are less viscous and have relatively more free flow. If the unsaturated oils are converted into saturated compounds they become saturated solid fats at room temperature. These solid saturated fats have more shelf life as they are chemically inactive and it is easy to transport them.

The process of converting liquid oils into solids saturated fats by passing hydrogen gas through them is called **hydrogenation** of oils. Finely divided nickel is used as catalyst during this process. Vanaspathi under different brand names is an example for hydrogenated oil or fat.

Think

How many hydrogen atoms should be added to Alkyne to make it Alkene? How many hydrogen atoms should be added to benzene to make it cyclohexane?

Remember

The addition reactions where hydrogen atoms are added, also called hydrogenation reactions.

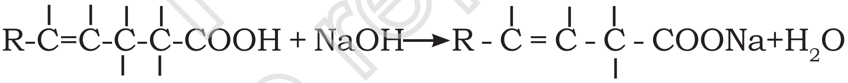
Recall

Fats / oils are not only nutrients to our body, but also useful to manufacture soap.

Fat/oil + water $\xrightarrow{\text{(hydrolysis)}}$ *fatty acid + Glycerol.*

Saponification value of an oil or fat

Saponification values of oil or fat are necessary to manufacture good quality soaps. **Saponification involves production of salts of patty acids starting from / oils.** It is the reaction that takes place between oil and sodium hydroxide during the manufacture of soap. The first step in this reaction is hydrolysis of fat or oil into carboxylic acid and glycerol. The second step is the formation of salt of the fatty acid by sodium hydroxide / potassium hydroxide.



$$R\text{-}C{=}C\text{-}C\text{-}C\text{-}COOH + NaOH \rightarrow R - C = C - C - COONa + H_2O$$

(Unsaturated fatty acids)

Saponification value can be defined as the amount of potassium hydroxide in 'mg' (milligrams) required to neutralize the fatty acid present in one gram of oil or fat. *In the manufacture of soaps it helps to prepare soap which does not contain excess of potassium hydroxide.*

Know this

Fats or oils are sources of food in which vitamins A,D,E,K are soluble. It is also a source of light for tribal people. Eskimos use animal fat as source of light in their igloos. They also use it as a source of heat.

Oils have been hydrogenated for many decades, to prolong their shelf life and make the oils more stable. Hydrogenated oil is oil in which the unsaturated hydrocarbon chain of fatty acid component is saturated.

Hydrogenated oil is far more stable, and will not go rancid as quickly as untreated oil. It also has a higher melting point, and is often used in frying and pastries for this reason. When hydrogenated, the chemical structure of the oil is changed, which scientists in the 1990s began to realize that it could result in negative health effects.

Know this

Paraffin wax and beeswax though look similar are different chemically. Paraffin wax is a hydrocarbon. Beeswax, a natural wax is manly esters of fatty acids and various long chain alcohols . It is used in cosmetics, preparation of dripless candles and skin ointments.

Everything that looks like oil is not really oil. Kerosine is not oil as it does not contain fatty acids. Glycerol which is used in medicines and cosmetics is obtained by the hydrolysis of oils.

Awarness

Next time You enter the grocery shop observe the label 'PUFA' on cooking oil packets.

PUFA : Poly unsaturated fatty acids

What are PUFA's?

Poly unsaturated fatty acids contain unsaturated hydrocarbon chain. Because of the presence of double bonds the PUFA reacts.

Exercise

I. Answer the following

1. Define saponification value. Why it is important?
2. Write the importance of hydrogenation of oils.
3. How are fats different from oils?

II. Fill in the blanks with suitable answers.

1. Fatty acid + glycerol ⟶ ____________ + water.
2. Catalyst used for hydrogenation of oils is ____________ .
3. On oxidation oils become ______________.

CHAPTER 13

INDUSTRIAL ORGANIC CHEMISTRY

SUCROSE AND ETHYL ALCOHOL

After studying this chapter you,

- distingnish between sugar and jaggery.
- recall the molecular formula of sucrose.
- give reasons for charring of sugar and starch when immersed in concentrated sulphuric acid.
- classify the carbohydrates into polysaccharides, disaccharides and monosaccharides.
- name the byproducts of sugar industry.
- explain the steps of manufacturing sugar from sugar cane.
- mention the uses of byproducts of sugar industry.
- recognise the necessity of preparing sugar instead of jaggery from sugar cane.
- state the molecular formula of ethyl alcohol.
- name the raw material used to manufacture ethyl alcohol.
- define fermentation.
- cite examples for fermentation in daily life.
- explain the steps of manufacturing ethyl alcohol from molasses.
- name the enzymes which convert sugar into alcohol.
- recognise the role of ethyl alcohol as a renewable motor fuel.
- give reasons for adding water and yeast to molasses during the manufacture of ethyl alcohol.
- distingnish between ethanol and methanol.

1. Sucrose

Sucrose is a type of disaccharide. Its molecular formula is $C_{12}H_{22}O_{11}$. The main source of sucrose are cane sugar or beet root sugar. A molecule of sucrose contains two monosaccharides. In other words one glucose molecule and one fructose molecule are bound to each other in a sucrose molecule.

$$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$$

Glucose+Fructuse→Sucrose+Water

Two structural formulae of sucrose.

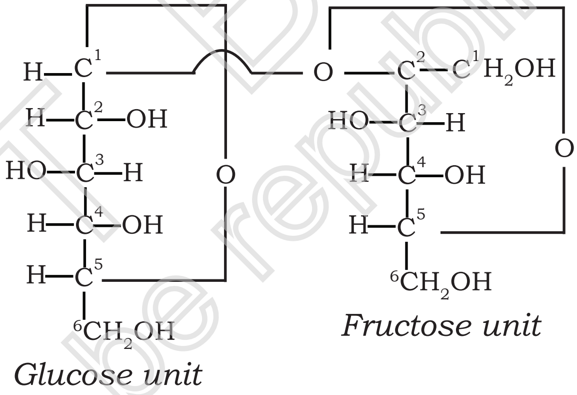


Fig. 13.1 Structural formula of sucrose. The molecule is made up of one glucose molecule and one fructose molecule. (Just observe the structure and do not practise it for examination).

Excercise 13.1

Collect information about monosaccharides, disaccharides and polysaccharides. Monosaccharides and disaccharides are sweet but polysaccharides such as starch, cellulose are not sweet. How is starch converted into monosaccharides in our body? you will study it in chemistry of food. After the digestion of food the starch should have been relished as a sweet substance if it reached the tongue. Is it true?

In modern days, sugar has become one of the essential commodity like salt in our kitchen. In ancient history there is no reference to the white crystalline sugar. But there is a mention of sugar in the Sanskrit books and it was called 'sharkara'. 'Sharkara' was obtained from the dried honey. People used to dry honey, store in earthern pot for several months.

Jaggery is almost sucrose containing natural colouring matter and some mineral ingredients. In Indian system of medicine use of jaggery is recommended more than white crystalline sugar. The reason for this may be the presence of useful nutrients, in addition to carbohydrate.

When sugar is heated to about 473K, it forms a sticky to chew the substance is called 'Caramel'. Caramel is used to make hard boiled sugar candy, and to coat the chocolates. It imparts a characteristic colour and flavour to food. At maximum concentration sugar is the best preservative to prepare fruit jams. Preservative is a chemical which increases shelf life of food items.

Think it over

Fruit juices mixed with sugar should be consumed quickly. If they are stored for hours or days, they turn sour and give a different taste. But thick sugar syrup can store the fruit juices for many days. Why? The aqueous solution of sugar undergoes chemical reaction called fermentation and turns sour. The duration for which the food items can be preserved is called shelf life.

If jaggery is easier to prepare than sugar, then why should we manufacture sugar? Human beings always wanted to invent substances which are durable and which have greater shelf life. When compared to jaggery the shelf life of sugar is more. It can be stored easily in any climatic conditions. White crystalline sugar is attractive also.

In this chapter, we shall briefly study about manufacture of sugar. Carbohydrates contain carbon, hydrogen and oxygen. Hydrogen and oxygen are present in the ratio of 2 : 1 in each molecule. Carbohydrates are classified into monosaccharides disaccharides and poly saccharides. Human beings can not digest cellulose which is a fibrous matter present in vegetables. We consume carbohydrates in the form of starch, disaccharides and monosaccharides. Starch is a natural polymer formed

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by many units of monosaccharides. Disaccharides are made up of two units of monosaccharides.

Activity 13.1

Add a pinch of starch, sucrose, and glucose in three separate test tubes. Add few drops of concentrated sulphuric acid carefully from the bottle using a glass tube. Wait for some time. You will notice that each substance in the test tube gets charred. What is the reason for this? Hydrogen and Oxygen present in the carbohydrates are absorbed by the sulphuric acid in the form of water. Leaving behind black residue carbon.

The liberation of heat makes the residue rise. Concentrated sulphuric acid is a good dehydrating agents.Can you suggest another method of dehydrating starch, sucrose or glucose?

Heat the substances gently by taking them in three separate test tubes. Duly labelled. What is your observation? Take a pinch of glucose in a test tube and add quick lime (calcium oxide). Wait for some time. Does the glucose in the test tube get charred? No. Quick lime is only a drying agent. Concentrated sulphuric acid is not only a drying agent but also a dehydrating agent.

Collect information

What is the difference between drying and dehydrating? These two terms have different meaning in chemistry, though the two are used almost with the same meaning in life sciences and in the medical field. In both drying and dehydrating the common factor is removal, of water.

Manufacture of sucrose or common sugar consists of the following steps-

i) Extraction of the juice from the source.
ii) Purification of the juice.
iii) Concentration and Crystallization
iv) Separation and drying of Crystals.

Sugar cane or sugar beet is cut into pieces, crushed in a series of roller mills. Maximum extraction of the juice is ensured. (The Cellulose material of the sugar cane residue is called bagasse. Bagasse is used as a fuel or as raw material to prepare cardboard which is known as celotex.)

The juice is warmed and run into settling tanks. It is then decanted from the sediment and made alkaline with calcium hydroxide. The impurities get precipitated. The liquid is steamed to coagulate protein matter and allowed to settle. The clear juice is concentrated into a syrup by evaporation under reduced pressure. The Syrup is cooled, to crystallise the sugar. The crystals are dissolved in hot water and decolourised with animal charcoal or with coconut shell charcoal which is called norit, and then filtered [In the preparation of Jaggery also the dark colour is slightly eliminated by adding a substance called hydrosol [sodium bi sulphate which generates sulphurdioxide and removes colour due to impurities]. The filtrate is concentrated and evaporated under reduced pressure to get a syrup which is crystallised to get white crystals of sugar.

Think

The white jaggery sometimes is salty to taste. Why?

Remember

Brown Sugar is not sugar. It is a hallucinating drug. The abuse of the drug spoils the bright future of many youths. One should not attempt to try such Psychotropic drugs, which have adverse effects on the health. If it is given to mentally ill patients, in suitable proportion, it may act as a medicine but its uncontrolled consumption and abuse results in the habit formation. The life of many youth is endangered by the habit. Caution: Do not attempt to try it by consuming in any form.

During the extraction of sugar all the syrup does not crystallize. A part of the syrup remains uncrystallized in the form of brown viscous liquid. The uncrystallized syrup is called molasses. It is best used as a raw material to manufacture ethyl alcohol in industries.

A liquid boils when its vapour pressure becomes equal to atmospheric pressure. The boiling point of water at an atmospheric pressure of 101.3 KPa is 373 K. But the same water can boil at 323 K or 343 K at higher altitude where atmospheric pressure is low. In the pressure cooker, the steam inside the cooker develops higher pressure and raises the boiling point of water. The food items get cooked quickly. The presence of salts also increase the boiling point of water. Super heated water is obtained by boiling water under higher pressure.

The container of the sugarcane juice is connected to vacuum pump and heated to evaporate water. If there is low pressure evaporation will be smooth. The separation of vapour will be at low temperature. The boiling takes place at a lower temperature and the sugar can be obtained at a lower temperature.

Think it over

What is evaporation under reduced pressure?

Know this

SI unit of pressure is pascal (Pa)
Kilo Pascal = 1000 Pa. 1 Pa = $1Nm^{-2}$. Atmospheric pressure at sea level is 76 cm of mercury column. It is expressed in Kilo pascals which is 101.3 KPa or 105 Nm^{-2} (approximately)

Activity 13.2

In a conical flask take about a cup of water. Boil the water, without closing the mouth of the flask. Steam produced drives away the gases present inside the flask. After 3 minutes of boiling, close the flask with a rubber cork. carefully cool the flask over running water from a tap. The steam inside the flask condenses and a region of low pressure is created inside the flask. You will notice the boiling of water inside the flask again when the flask is being cooled.

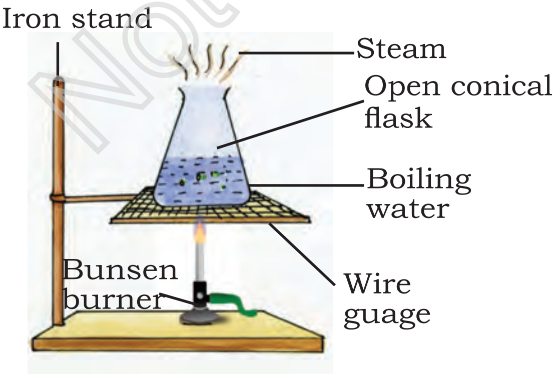


Fig.13.2 Driving away the air by steam

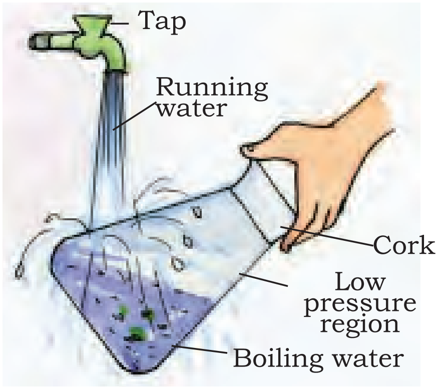


Fig.13.1 Boiling under reduced pressure

Find out

From a medical practioner find out the meanings of the terms, hypoglycemia and hyperglycemia. Which harmone controls the blood sugar levels in our body?

Know this

All that is sweet in taste are not sugars. Glycerol which is sweet in taste is not a sugar solution. Sucrose can be tested by heating its aqueous solution with hydrochloric acid and then by adding Fehling's solution [Alkaline copper sulphate solution]. to get a reddish precipitate. Diabetic patients sometimes use artificial sweeteners which are not sugars. Sugar test for diabetic patients is test for amount of glucose in the blood or urine.

Manufacture of ethyl alcohol from sugar

You have studied that during the manufacture of sugar, a part of the sugar cane syrup remains uncrystallised. The viscous brown liquid is called molasses. In industry molasses is used to manufacture ethyl alcohol or ethanol. The molecular formula of ethanol is C_2H_5OH. In this chapter we shall study about the method of manufacturing ethyl alcohol from molasses. The process is one of the oldest techniques. Invariably all sugar industries have alcohol manufacturing unit also.

Think

Grape fruit or juice if kept for several days lose its original flavour and taste. But grape fruits if dried in sunlight to get raisins do not decay. Drying of fruits is one of the method of preserving fruits during the season of its availability.

You might have observed the method of preparing curds, Idli and dosa batter at home. How is it done? A spoon of curds prepared earlier is added to luke warm milk in a vessel and kept overnight under normal temperature. Curds will be ready the next day. Water soaked rice and black gram dhal are ground into fine paste and kept in the vessel half filled, overnight. The next day the idli or dosa batter rises up and fills the entire vessel. The frothy appearance gives an impression that it is being boiled. The word fermentation is derived from the greek language, which means boiling. There will not be any boiling but an apparent resemblance of boiling.

Milk turning into curds, the batter of idli and dosa rising up, the spoilage of cooked wet food items are examples of fermentation. Fermentation is a chemical decomposition produced by micro organisms on certain organic matters. Usually carbondioxide is produced during fermentation. Suitable temperature range and dilution of the matter are necessary to increase the rate of fermentation reaction.

The matter which undergoes fermentation is called substrate. The micro organisms which enter the matter produce a specific type of enzymes which act like organic catalysts to decompose the substrate.

Fermentation of molasses include three steps

i) Dilution of molasses by water such that the solution contains about 10% Sugar.

ii) Addition of yeast and maintaining the temperature range of 308 K to 313 K.

iii) Distillation of the fermented matter.

Molasses is diluted with water and acidified by adding dilute sulphuric acid. Yeast is added to the solution and the container is closed. The temperature is maintained around 308 K. Fermentation takes place in about a week. The fermented matter is called 'wort' and it contains about 6 to 10 percent alcohol. It is fractionally distilled to obtain 95% alcohol. The reactions are.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Invertase}]{\text{Enzyme}} \underset{\text{Glucose + Fructose}}{C_6H_{12}O_6 + C_6H_{12}O_6}$$

$$C_6H_{12}O_6 \xrightarrow[\text{Zymase}]{\text{Enzyme}} 2C_2H_5OH + 2CO_2\uparrow$$

Glucose or Fructose ⟶ Ethanol + Carbon dioxide

Think it over

Sugar solution which is not concentrated undergoes fermentation but not thick syrup of sugar.

Milk turns into curds very quickly and becomes sour in summer. In winter season curd takes more time to form. Why?

Find out the name of the micro organism which turns milk into curds.

Know this

Though ethanol [Ethyl alcohol]. is present in most of the intoxicating drinks, it can also be used as fuel. KSRTC of Karnataka is already using ethanol blended diesel as fuel. This helps in the better management of non renewable and renewable sources of energy.

Alcohol and Ayurveda

In many ayurvedic tonics self generated alcohol is present to a small extent. It stimulates and improves appetite. But methyl alcohol or methanol [CH_3OH]. Is a poisonous substance, even at low concentration.

Exercise

I. For each of the following statements or questions four alternatives are given. Choose the most appropriate alternative:

1. The vegetable that contains more sucrose is,

   a. radish.

   b. beet root.

   c. potato.

   d. green leaves.

2. The products formed when a pinch of sugar is strongly heated for fifteen minutes in a test tube are,

   a. carbon and water vapour.

   b. carbon, hydrogen and oxygen.

   c. carbon dioxide and water vapour.

   d. carbon dioxide and hydrogen.

3. The residue of sugarcane from which the juice is extracted can be used to prepare,

   a. manure.

   b. card board.

   c. alcohol.

   d. building material.

4. During the evaporation of cleaned sugarcane juice, pressure surrounding it, is reduced to,

   a. increase the boiling point.

   b. maintain the boiling point at 373 K.

   c. decrease the boiling point.

   d. increase the size of the sugar crystals.

5. Molecular formula of ethanol is,

   a. CH_3OH b. $C_2H_4(OH)_2$

   c. C_2H_5OH d. HCHO

6. The fermented matter of molasses is called,

   a. raw material. b. wort.

   c. bagasse. d. precipitate.

II. Fill in the blanks :

1. Molasses is used to prepare ___________.
2. The molecular formula of sucrose is ___________.
3. Carbohydrates contain hydrogen and oxygen atoms in the ratio of ___________.
4. The protein matter in the sugarcane juice is coagulated by ___________.
5. The substrate on which Invertase acts is ______________ .
6. Zymase converts Glucose or Fructose into ______________ .

III. Give reasons for the following :

1. Coconut shell charcoal is used in the manufacture of sugar.
2. The shelf life of sucrose is more than that of jaggery.
3. Evaporation of sugarcane juice syrup is done under reduced pressure.
4. Saturated sugar solution is sweeter than the solid sugar itself.
5. Grape fruits get spoiled easily but not the dry grapes.
6. Use of Ethanol as fuel conserves fossil fuels.
7. All microorganisms are not harmful

IV. Answer the following :

1. Sulphur dioxide gas is also used in some sugar industries to manufacture sugar. What is the property of sulphur dioxide applicable in this case?

2. What is molasses?

3. Briefly explain the steps of manufacturing sugar from sugar cane.

4. Why does a piece of cotton cloth get charred when immersed in concentrated sulphuric acid?

5. In which form do carbohydrates get assimilated in our body?

V. Discuss :

1. There are more friendly bacteria than harmful bacteria.

2. The ecological balance is maintained by bacteria.

3. Our intestines become weak whenever we consume strong antibiotics for the bacteria related diseases.

4. To make bread, yeast is used but not to make chapathi.

* * *

CHAPTER 14

SOUND

After studying this chapter you

- enlist the properties of sound.
- conduct experiments to verify that the sound affects matter.
- state the condition for the echo to be heard.
- make a list of the uses of echo.
- solve problems related to echo.
- explain the uses of ultrasonic waves.
- define Doppler Effect.
- identify Doppler Effect in day to day life.
- explain the working of SONAR.
- make a list of the uses of Doppler Effect.
- identify the use of RADAR.

Sound is a wave and a form of energy which has enabled us to know what is happening around us. The study of sound waves has helped us to know how speech is produced. In fact it has helped the physiologists to develop techniques to correct speech impairment. The sound produced by the heart and lungs can signal the medical problems. Improvement of acoustics in theatres, concert halls is possible only by studying the properties of sound.

Is it not a wonder to note that human beings are capable of evolving language through the ability to produce diverse sounds!

Can sound affect matter?

In the eighteenth century German scientist and musician Ernst Chladni demonstrated that vibration of sound can affect matter. He drew a violin bow around the edge of a plate covered with fine sand. The sand formed various geometric patterns.

Fig 14.1
Ernst Chladni

Activity 14.1

Keep a plate on a vessel and spread saw dust on the plate. Hit the tuning fork against the rubber pad. Keep the vibrating tuning fork on the plate. What do you observe?

Think

What happens when a paper piece (as a rider) is placed on the string of the musical instrument Veena, and pluck the string. Why ?

You have already learnt the properties of sound and reflection of sound in your previous class. In this chapter you will be learning more about interesting properties and effects of sound which helps you to know the world in a better way.

Activity 14.2

Take a 50 ml syringe and fit a buzzer and connect it to a 9 V battery, as shown in the figure 14.2. When the current flows through the circuit, you can hear the sound. Closing the nozzle of the syringe, pull down the piston. What happens and why?

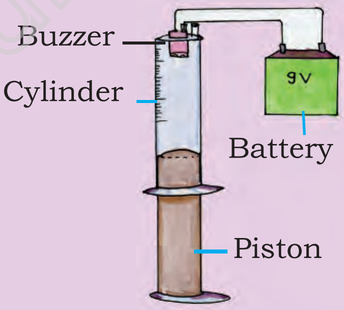


Fig14.2

Echo

It is a common observation that sometimes if we shout or clap near a tall building or a mountain, or any suitable reflecting surface, we will hear the same sound again a little later.

The sound heard after reflection from a rigid surface (such as hill, wall of a building, cliff etc), is called **Echo**.

Imagine that you are standing in front of a cliff which is at a distance ‘d’ from you. And let the speed of sound in air be ‘v’. Suppose you shout, the distance covered by the sound to reach the cliff and come back to you is ‘2d’ and the time taken is ‘t’.

$$t = \frac{\text{total distance travelled}}{\text{speed of sound}} = \frac{2d}{v}$$

The sensation of sound persists in our ear for about 0.1 s. To hear a distinct echo the time interval between the original sound and the reflected sound must be later or equal to 0.1 s.

By substituting t=0.1 s and v=340 ms^{-1} in air.

$$d=\frac{340 \times 0.1}{2} = 17m$$

Therefore to hear the echo distinctly, the reflecting surface should be at a minimum distance of 17 m from the listener.

Think

Why is an echo weaker than original sound?

Numerical

A boy standing in front of a hill, claps. He hears an echo after two seconds. The speed of sound in air is 340 ms^{-1}. What is the distance of the hill from him?

Let the distance between the boy and the hill be 'd'. Total distance travelled by the sound

$$v=\frac{2d}{t} \qquad d=\frac{v \times t}{2}$$

$$d=\frac{340 \times 2}{2} = 340 \text{ m}$$

The distance of the hill from the boy is 340 m.

Interesting facts about echo

Echoes may be heard more than once. This is due to multiple reflections from number of reflecting surfaces.

The roaring of thunder is due to multiple reflections of sound from many reflecting surfaces of clouds.

In the Whispering gallery of Golgumbuz at Bijapur, sound is echoed seven times.

Fig 14.3 Mountain lake Killarney-Ireland

The most remarkable echo in the world is produced by mountain lake Killarney, Ireland. A shout or a word is repeated by almost hundred times.

Ultrasonic Sound

You already know that sound is produced when a body vibrates in a particular range. Even though an object vibrates in a wide range of frequencies, we can hear the sound produced by a body which vibrates with a particular range of frequency.

So, what should be the range of frequency of the vibrating body, if it has to produce an audible sound?

In fact that range is 20 Hz to 20,000 Hz. These frequencies are called Audible Frequencies and the range is called Audible Range.

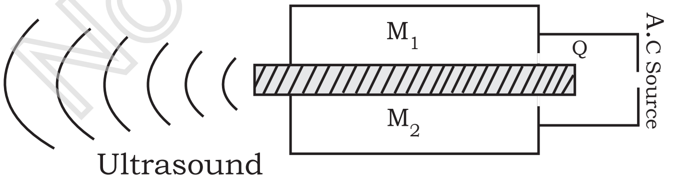
The sound produced by bodies which vibrate with the frequency less than 20 Hz or more than 20,000 Hz is not audible by human beings.

The sounds of frequency below 20 Hz are called infrasonic sound or subsonic sound.

Sounds of frequencies beyond 20,000 Hz (20 kHz) are called **ULTRASONIC SOUNDS.** The branch of Science that deals with ultrasound is called **Ultrasonics.** Animals like dogs, cats and bats can hear ultrasonic sound.

There is no difference between sound wave and ultrasonic wave except in frequency. As ultrasonic sound has high frequency, it has high energy.

A thin quartz slice is placed between two thin metallic plates. And the metallic plates are connected to an A.C source of frequency more than 20 kHz. When the current flows through the metallic plates, the quartz slice vibrates with a frequency more than 20 kHz producing ultrasonic sound.



M_1 and M_2 - Metallic plates

Q = Thin quartz plate.

Fig 14.5

Uses of ultrasonics

Ultrasonic waves are useful because of their mere propagation.

By studying the ultrasonic waves passing through a medium, we can infer about its physical properties like elasticity, configuration of atoms.

Ultrasonic waves can be used to detect cracks and flaws in metal mouldings. Ultrasonic waves are passed through metal mouldings and transmitted waves can detect the flaws. If there is any defect, the ultrasound gets reflected back showing the defect.

How can bats fly unerringly during nights?

Bat can produce and hear sound of frequency up to 100 kHz. The sound produced by flying bat gets reflected from obstacle in front of it. By hearing this reflected sound, it can detect the obstacle even during nights.

Ultrasonic waves are useful because they have high frequency.

Two immiscible liquids can be homogenized by using ultrasonic waves. Therefore these waves are used in manufacturing of alloys and manufacturing emulsion for photographic films. They are used in dry cleaning to remove grease and dirt. They can serve as insect repellants. These waves can kill bacteria. And also used for sterilization purposes.

Coming to the medical field, they are used to cure neuralgic and rheumatic pains. Surgical instruments vibrating at ultrasonic frequencies are used in bloodless surgery. They are also used to break gallstones.

Dolphins and sound imaging

Dolphins emit ultrasonic waves to locate and identify objects in its environment. Distance is sensed by time delay between sending sound and receiving the echo.

Sonar

Animals (Dolphins and Bats) have used sound for communication and object detection for millions of years. In 1930's American engineers developed their own under water sound detection technology. During the Second World War, Americans began to call this technology as SONAR.

SONAR is an acronym of "Sound Navigation and Ranging". This is a technique by which ultrasonic waves are used to measure the distance, direction and speed of underwater objects.

This is a very useful technique by which the depth of the sea can be determined. This can also be used to locate underwater hills, valleys, submarines, icebergs and also sunken ships.

Sonar consists of a transmitter and a detector in a boat as shown in the diagram.

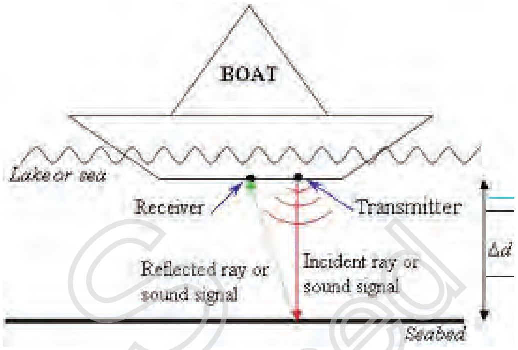


Fig 14.5 Sonar

The transmitter produces and transmits ultrasonic waves. These waves travel through water until they strike an object. They get reflected and the reflected waves return to the sonar and are sensed by the detector. The detector converts the ultrasonic waves into electrical signals which are interpreted. The time interval between transmission and reception is recorded. The distance of the object is calculated.

Let the time interval between transmission and reception of the ultrasonic sound be ‘t’ and the velocity of sound through water be `v’.

Then the distance‘d’ of the object is given by $d = \frac{vt}{2}$.

The above method is called Echo-ranging.

Numerical Example

A ship sends ultrasonic sound, it returns from seabed and it is detected after 4 s. If the speed of ultrasonic sound through seawater is 1.5 Kms^{-1}, what is the depth of the sea?

Given, Time between transmission and detection of ultrasonic wave, t=4 s

Speed of ultrasonic wave in water, v=1.5 Kms^{-1}

Let the distance travelled by the ultrasonic wave, d= 2x Depth of the sea.

$$v = \frac{2d}{t} \qquad d = \frac{v \times t}{2}$$

$$d = \frac{1.5 \times 4}{2} = 3 \text{ km.}$$ Depth of the sea = 3 km.

Ultrasound Scanning

Sound ranging is used to get the images of internal organs of human body. This is called ultrasound scanning. It is a very important technique by which the information about the internal organs like bladders, kidneys, ovaries, pancreas can be obtained without disturbing the human body. It is very widely used as it is less harmful than X-ray. When the ultrasound is used to examine the heart it is called Echo Cardiography. It is used in diagnosis of heart diseases.

Another important application of ultrasound imaging is examination of the foetus during pregnancy to detect congenial and growth abnormalities.

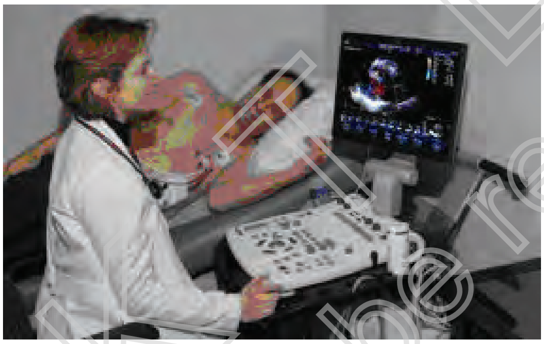


Fig 14.6 Echocardiography

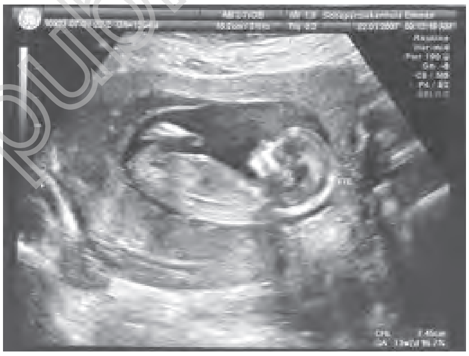


Fig 14.7 Ultrasound scanning to examine the foetus

Ultrasonic waves can be directed to specific area of human body. Ultrasound travels freely through fluid and soft tissues. However, ultrasound is reflected back (it bounces back as 'echoes') when it hits dense surface. For example, the ultrasound will travel freely though blood in a heart chamber. But, when it hits a solid valve, ultrasound echoes back.

How does an ultrasound scanner work?

The operator places a probe (it is like a very thick blunt pen) over the part of the body to be examined, lubricating jelly is put on the skin so that the probe makes good contact with your body. The probe is connected by the wire to the ultrasound machine and monitor. Pulses of ultrasound are sent from the probe to the body. The ultrasound bounces back from the various structures in the body. This is detected by the probe and sent down the wire to the ultrasound machine. They are displayed as a picture on the monitor.

doppler effect

The velocity of the wave depends on the medium. As long as the medium is the same, the velocity, frequency and wavelength do not alter. But when either the source of the wave or observer is moving relative to each other, then there is an apparent change in the frequency of the wave. This is known as the Doppler Effect.

There is an apparent change in the frequency of wave, whenever there is a relative motion between the source of sound and observer. It is called Doppler Effect named after the scientist Christian Doppler who observed this first.

Fig 14.9
Christian Doppler

When can we observe Doppler Effect?

In order to observe Doppler Effect, either the source or the observer or both have to move relatively.

Doppler Effect is not observed when the observer and the source are stationary or the observer and the source move with the same velocity in the same direction. As both sound and light are waves, Doppler Effect is observed in both sound and light.

When the source of the sound is moving towards the observer at rest, the waves on front appear to be compressed. The wave length decreases. She receives more number of waves, than when the source of sound was static. The observer feels sound to be of higher frequency. Therefore he feels the pitch of the sound to be higher.

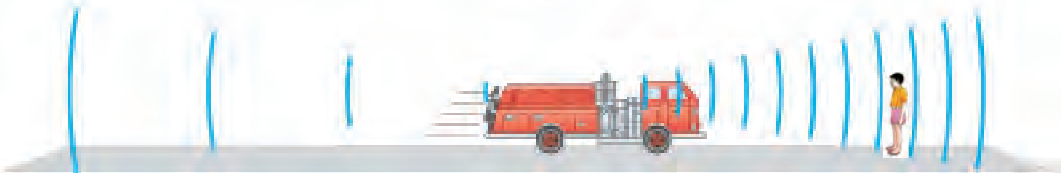


Fig 14.9 : Fire engine moving towards the stationary observer

The same effect is observed when the observer is moving towards a stationary source of sound.

When the source of the sound moves away from the observer, the waves behind the source appear to be farther apart. The wave length increases. He receives fewer number of waves. The observer feels the sound to be of lower frequency. Therefore he feels the pitch of the sound to be lower.

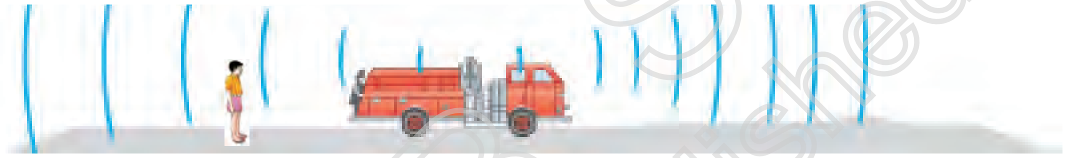


Fig 14.10 : Fire engine away from the stationary observed

The same effect is seen when the observer moves away from a stationary source of sound.

Think

Can you find out what happens to the frequency of the sound when

(1) both the observer and the source approach each other ?

(2) both observer and the source move away from each other with a different velocity ?

Applications of doppler effect

Doppler Effect can be used to track artificial satellites.

Doppler Effect in sound can be used to determine the velocity of submarines.

When the source of the light wave moves away from the observer with a velocity comparable to that of light, the frequency of the light noticed will be less and hence it shifts towards the red end of the spectrum. This is called red shift. The study of the spectrum of the stars indicates that all stars in the universe are moving away from us at very high speed. This results in expansion of the universe.

The measurement of this shift helps in the calculation of speed at which they are receding from us.

Astronomers use this effect to gauge the movement of stars with relative to earth.

When the source of light wave approaches the observer with a, velocity comparable to that of light, the frequency of the light noticed is high. Hence it shifts to blue end of the spectrum, it is called blue shift.

Radar

Ultrasonic wave requires a material medium for its propagation. When an artificial satellite has to be tracked ultrasonic waves cannot be used as it cannot travel in vacuum. More over the ultrasonic wave loses its energy to the medium in which they travel. As a solution to these problems a new technique called RADAR was developed. It is an acronym of “Radio Detection and Ranging”. It works very similar to that of SONAR, but electromagnetic wave used in the place of ultrasonic wave.

In 1886 a German Physicist Heinrich Hertz showed that radio waves could be reflected from metallic objects.

This discovery led to the development of Radar. Radar is an object detecting system which uses electromagnetic wave specially radio wave to determine the range, altitude, direction or speed of both moving and fixed objects.

Know this

Electromagnetic waves can travel very large distances. Therefore Radar can track the objects which are at huge distances. The challenge is, time taken by the radar to cover the distance is very less. Hence we require an accurate instrument which can measure very small time interval of the order of microsecond.

Radar (like sonar) sends a pulse of electromagnetic radiation and then detects the reflected wave after it bounces off the target (aircraft, vehicles etc.) By knowing the speed of radio wave and the time taken for the signal to bounce off the object and hit the receiver the distance of the object can be detected. A radar operator can gauge the distance between himself and the object.

Radar Antenna
Fig 14.11

Radar is used to track the aircraft, artificial satellites and motor vehicles.

Traffic control authorities use Doppler Effect to detect vehicles crossing speed limit. Radio waves are used for this purpose. Radio waves are sent in the direction of the speeding vehicles and the reflected waves are received. The change in the frequency of the waves is used to determine the speed of the vehicle. The instrument used for this purpose is called **Radar Gun.**

Fig 14.12
Radar Gun

Exercise

I. Four alternatives are given to each of the incomplete statements/questions. Choose the answer

1. Echo of sound is due to ______________of sound

   a) propagation b) reflection

   c) refraction d) speed

2. The property of ultrasonic waves used in manufacturing emulsion for photographic films is its, __________________

   a) high speed b) high frequency

   c) higher wavelength d) high amplitude.

3. When a source emits light of particular wavelength and the source is moving away from us, the wavelength appears ______________.

   a) longer b) first longer and then shorter

   c) unaltered d) shorter

4. The audible range in humans is__________

   a) 20 Hz to 2000 Hz b) 200 Hz to 20,000 Hz

   c) 20 Hz to 20,000 Hz d) 200 Hz to 20 kHz.

5. The speed of ultrasonic sound in air is____________

   a) 3×10^8 m s^{-1} b) 340 m s^{-1}

   c) 1500 m s^{-1} d) 4500 m s^{-1}

II. Complete the following statements

1. The sound wave is of the type ____________ .
2. Ultrasonic waves is preferred to X-ray in medical field because __________ .
3. When ultrasound is used to examine heart, it is called____________
4. The shift caused in visible spectrum of light emitted by galaxies is ____________.

III. Match the following

	A		B
1.	Radar	a)	apparent shift in frequency
2.	Sonar	b)	audible sound
3.	Doppler Effect	c)	electromagnetic radiation
		d)	ultrasound
		e)	ultraviolet rays.

IV. Answer the following questions

1. What is an echo? Mention the condition for the echo to be heard.
2. An ultrasonic sound sent from a ship travels with the speed 1530 ms^{-1} in sea water. How deep is the water if the time delay of the echo from the sea bed is 6 s?
3. What is SONAR? How does it work?
4. What is Doppler Effect? Explain with an example.
5. Mention three applications of Doppler's effect.

CHAPTER 15

METALS

This chapter facilitates you

- distinguish between a metal and a non metal.
- recall the chemical properties of metals.
- write the equations of chemical reactions of metals.
- define ore.
- recall the metallic ores that occur in Karnataka.
- explain the different methods of concentrating ores.
- explain the steps of the method of extracting iron from hematite.
- draw the diagram of blast furnace used in the extraction of iron.
- explain the steps of extracting aluminium from bauxite.
- draw the diagram of electrolytic cell used in the extraction of aluminium.
- explain the different methods of refining a metal.
- recognise the alloys used in our daily life.
- recall the constituents of different alloys.
- make a list of the advantage of alloy over pure metals.
- state the special properties of alloys.
- make a list of the contribution of Indians in the development of good quality alloys.

The earliest classification of elements was metals and non metals, based on the common properties of elements. Most of the elements are metals. The number of nonmetals is very less. But the nonmetals are abundant when compared to metals in the earth crust. You have already studied about the diffrences between a metal and a nonmetal.

Exercise 15.1

Classify the following into metals and nonmetals.

Mercury, Gold, Calcium, Bromine, Oxygen, Sodium, Sulphur and Magnesium.

In the classification you might have used your previous knowledge. If you are given two pieces of elements in solid state of the same size and painted with the same colour, how do you identify whether they are metals or nonmetals?

Gently drop the two pieces separately from your knee height. Did you hear a characteristic sound like that of a coin slipped from your hand? Metals are sonourous in the sense that they produce a typical sound. Metallic vessels, tumblers, musical instruments produce a recognisable sound, Can you use this property alone to distinguish between a metal and nonmetal? A streched rubber band or streched leather as in the instrument ' Tabla' also produce such type of sound. Similarly sodium metal cannot make such a sound. You can apply another property namely electrical conductivity to identify a metal. Though it is a good technique, there is a nonmetal graphite which is an allotrope of carbon that conducts electricity. There are certain general set of physical and chemical properties which are characteristic to metals and nonmetals. By applying these properties we can distinguish between metal and nonmetal. Not a single property can decide the material as metal or nonmetal.

Table 15.1 : General characteristics of metals and nonmetals

Part I : Differences in Physical properties.

	Metal		Non metal
1	Solids at room temperature (Except Mercury and gallium which are in liquid state)	1	Occur in all the three states namely, solid, liquid and gaseous state
2	Sonorous [There are exceptions]	2	Non sonorous
3	Generally malleable and ductile	3	Brittle
4	Generally conduct Electricity. Conductivity differs from metal to metal	4	Do not conduct electricity (except graphite)
5	Generally conduct heat.	5	Do not conduct heat (except graphite and diamond)
6	Lustrous [Freshly cut sodium metal loses its lustre quickly due to the action of atmospheric gases.	6	Non lustrous, (iodine, graphite silicon have slight metallic lustre. These are exceptions)

Part II : Differences in chemical properties

1	Electron donors and hence electropositive	1	Electron acceptors and hence electronegative (hydrogen is termed nonmetal, but it is electro positive, at very low temperature hydrogen shows metallic properties.)
2	Generally form ionic bond	2	Generally form both ionic and covalent bond
3	Generally displace hydrogen from dilute acides. (except copper, gold, silver, platinum)	3	Do not displace hydrogen from dilute acids.
4	Aqueous solutions of metallic oxides turn red litmus blue. Matallic oxides are basic. Oxides of zinc and aluminium are amphoteric in the sense that they form salt and water with a base as well as with an acid [Some metals directly react with water]	4	Aqueous solutions of nonmetallic oxides turn blue litmus red. Non metallic oxides are acidic. Nonmetallic oxides such as nitrous oxide, carbon monoxide are neutral oxides. They do not dissolve in water.
5	Some oxides of metals in aqueous solution react with zinc to produce hydrogen	5	Aqueous solutions of oxides of nonmetals react with carbonates producing carbon dioxide.

Exercise 15.2

Classify the following into acidic, basic, amphoteric and neutral oxides.

1. Magnesium axide 2. Carbon dioxide 3. Carbon monoxide

4. sulphur dioxide 5. Zinc oxide 6. Calcium oxide.

Metallic and non metallic compounds have variety of uses in our daily life.

You have studied some of the chemical properties of metals in the previous class. Let us briefly recall the chemical properties of metals.

I. Action of air on metals

Think

Many metallic articles lose their lustre when exposed to air for many days. You might have seen cleaning of metal surfaces using tamarind or mild acidic chemicals. Can you give reason for these common observations?

Example 15.1

Iron rusts in moist air forming hydrated ferric oxide (Molecular formula $Fe_2O_3 . 2H_2O$). To prevent rusting, surface of iron is painted or coated with metals like zinc or chromium. Rusting is a process of oxidation. Tin containers, are not made from tin. Mild steel containing more than 99% iron is are coated with tin. When the coating wears off they start rusting. Why is tin selected for coating?

Example 15.2

Magnesium ribbon kept carelessly exposing it to air, aluminium utensils made from recyled aluminium also form a rust. This rust will be greyish white in colour.

Example 15.3

Loss of lustre by some metallic articles which are exposed to air over long period of time is due to the formation of oxide, hydroxide and carbonate layers.

Example 15.4

Metals like sodium and potassium which are not used in our daily life but used for laboratory experiments and in industries are so reactive, form oxides, hydroxides and carbonates with oxygen, water vapour and carbon dioxide present in the air. They are stored under kerosene to cut off the contact with the air. Kerosene does not react with sodium or potassium.

> ***Think***
>
> *Petrol also does not react with sodium or potassium. But it is not selected for preserving sodium or potassium metals. Why?*

Example 15.5

Certain metals react with air when heated up to their ignition temperature. The ractions are exothermic and produce high temperature. Under high temperature, the surrounding particles of the burning metal glow with dazzling white light. You might have seen the aluminium powder of a sparkler, crackers and fireworks burning with a white light.

$$2Mg + O_2 \longrightarrow 2MgO$$

$$4Al + 3O_2 \longrightarrow 2Al_2O_3$$

> ***Note***
>
> During the burning of a magnesium ribbon, not only magnesium oxide is formed but also a small quantity of magnesium nitride due to high temperature. The high temperature breaks the triple bond between nitrogen atoms of its molecule which can otherwise happen during lightening. Recall the electrochemical fixation of nitrogen that you have studied in life sciences.

II. Action of other non metals on metals.

- With nitrogen, metals form respective nitrides at a high temperature.

  $3Mg + N_2 \longrightarrow Mg_3N_2$ magnesium nitride.

- With hydrogen metals form respective hydrides.

  $Ca + H_2 \xrightarrow{heat} CaH_2$ calcium hydride.

- With cholorine metals form respective chlorides.

  $2Al + 3Cl_2 \xrightarrow{warm} 2AlCl_3$

- With sulphur metals form respective sulphides.

  $Fe + S \xrightarrow{heat} FeS$ Ferrous sulphide.

III. Action of water on metals.

We store water in metallic containers and we also cook food, boil water in metallic containers. Commonly used metals do not react with water easily. But they react under different experimental conditions.

i) $2Na + 2H_2O \longrightarrow 2NaOH + H_2\uparrow$ (Cold water) [Recall the experiments that you have studied in 8th Standard]

ii) $Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2\uparrow$ (Impure magnisium and boiling water)

iii) $Zn + H_2O \longrightarrow ZnO + H_2\uparrow$

iv) $Mg + H_2O \longrightarrow MgO + H_2\uparrow$

v) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2\uparrow$

(In these reactions metals are heated to red hot state and water in the form of steam should be passed over them.)

Some metals react very fast with water. Some metals react very slowly with water. Metals that do not react with water are plantinum and gold.

Experiment 15.1

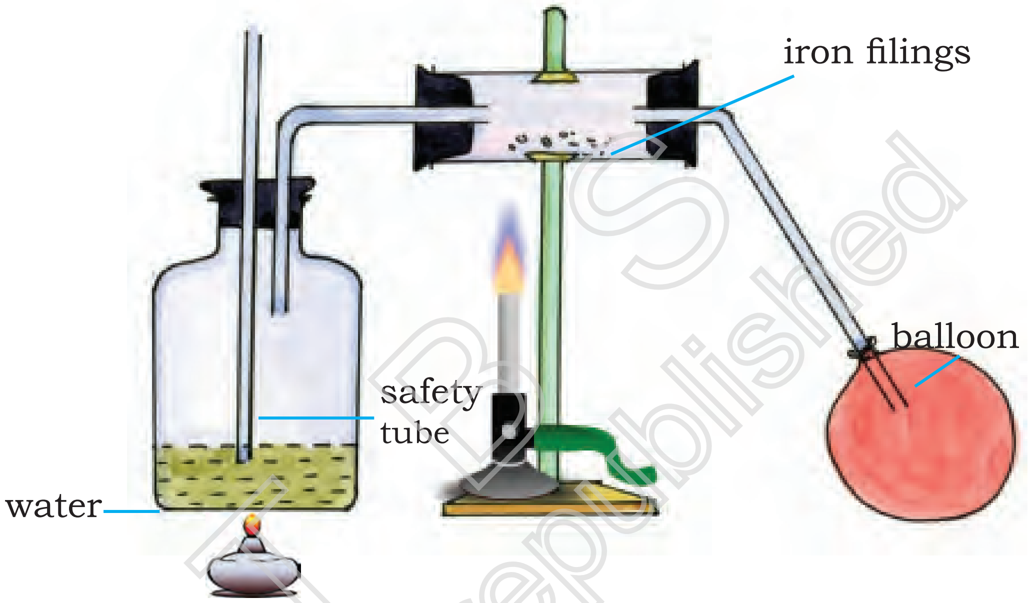


Fig 15.1 Lane process of manufacturing hydrogen

In a hard glass Borosilicate tube with both the sides open take about 5 grams of iron filings in a horizontal position and arrange the apparatus as in figure No.15.1. Collect the hydrogen gas in a ballon and fill the ballon. Tie the mouth of the ballon with a thread and release it. The ballon goes up and sticks to the roof of the room. It is because hydrogen gas is the lightest gas. Do not try to ignite the hydrogen gas as it is dangerous. In the above experiment the oxide of iron obtained is called ferricoxide or ferrosoferric oxide. The above process is also called **Lane process** of manufacturing hydrogen.

Note

Experiment No. 15.1 takes some time. If you do not get sufficient hydrogen gas to fill the ballon, fill the ballon by hydrogen gas from the experiment 15.2.

Recall

Name the products of electrolytic decomposition of acidified water. Hydrogen gas can be manufactured by different methods.

IV. **Action of dilute hydrochloric acid on metals**. Metals like zinc, aluminium, magnesium react with dilute hydrochloric acid to form respective chlorides liberating hydrogen gas.

Experiment 15.2

In a large borosilicate test tube take about 10 'g' of zinc granules. In a separate beaker take about 30 cm^3 of water and slowly add 20 cm^3 of concentrated hydrochloric acid to the beaker. Now the beaker contains dilute hydrochloric acid. Add dilute hydrochloric acid to the test tube upto half its volume. You will observe air bubbles. Fix a cork with a rubber tube to the test tube. Pass the gas through a liquid soap as shown in figure No.15.2. Soap bubbles rise up. Ignite the soap bubbles with a burning match stick. Take the help of your classmate for this experiment. What happens? Hydrogen is a combustible gas. It combines with oxygen of the air when ignited. $2H_2 + O_2 \longrightarrow 2H_2O$.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2\uparrow$$

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2\uparrow$$

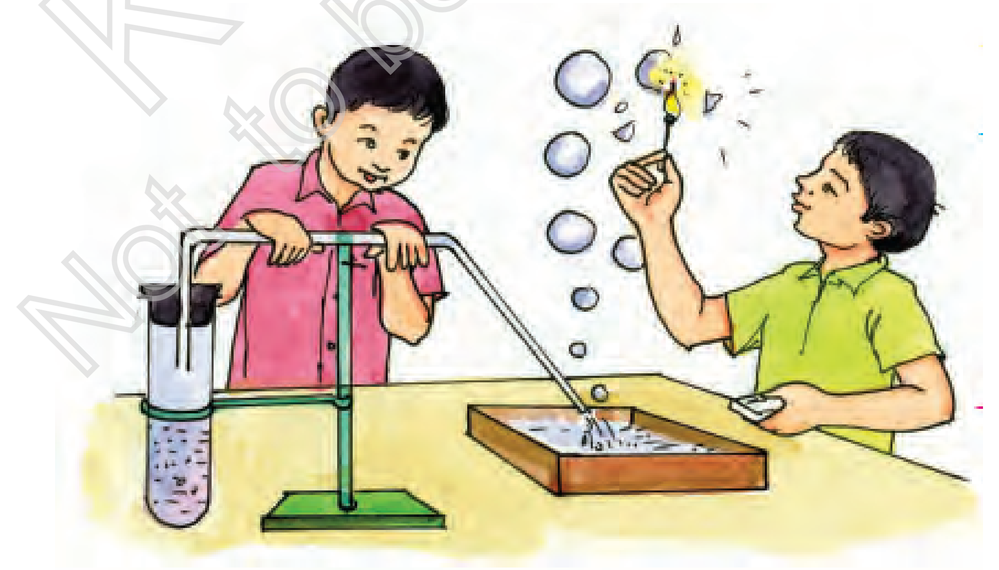


Fig 15.2 Experiment to demonstrate action of dilute hydrochloric acid on metals

Note

In the experiment No. 15.2 If you use magnesium or aluminium instead of Zinc, the acid has to be diluted by adding little more water, Aluminium or magnesium are more reactive than zinc.

Know this

If you use concentrated hydrochloric acid instead of dilute hydrochloric acid to prepare hydrogen gas using zinc metal, you get the same products. But the reaction will be vigorous and chemicals spill out of the test tube.

V. Action of dilute sulphuric acid on metals.

Metals like zinc, magnesium, iron react with dilute sulphuric acid to form respective sulphates liberating hydrogen gas.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

Exerise 15.3

Write the equations of chemical reactions taking place between

i) Magnesium and dilute sulphuric acid.

ii) Iron and dilute sulphuric acid.

VI. Action of concentrated sulphuric acid on metals.

In 8th standard you have studied about the method of preparation of sulphur dioxide in the laboratory. Recall the experiment and the chemicals used.

$$Cu + 2H_2SO_4 \xrightarrow{heat} CuSO_4 + SO_2\uparrow + 2H_2O$$

If zinc or magnesium metal is used instead of copper the rate of reaction increases, and heating of the reactants should be controlled.

$$Zn + 2H_2SO_4 \dashrightarrow ZnSO_4 + SO_2\uparrow + 2H_2O$$

VII. Reaction of very dilute nitric acid on metals.

Very dilute nitric acid reacts with Zinc and Magnesium metals to liberate hydrogen gas. Example: $Mg + 2HNO_3 \dashrightarrow Mg(NO_3)_2 + H_2\uparrow$

Nitric acid is a good oxidising agent and gets itself reduced to oxides of nitrogen, when reacts with metals. It behaves differently with different metals. Degree of dilution also decides the nature of products. However two common reactions of nitric acid on the metal copper are given here

copper + moderately diluted nitricacid ⟶ copper nitrate +nitric oxide + water.

$$3Cu + 8HNO_3 \longrightarrow 3Cu\ (NO_3)_2 + 2NO\uparrow + 4H_2O$$

Copper + concentrated nitric acid ⟶ copper nitrate + nitrogen dioxide + water.

$$Cu + 4HNO_3 \longrightarrow Cu\ (NO_3)_2 + 2NO_2\uparrow + 2H_2O$$

Experiment 15.3

In a large borosilicate test tube take about 10 'g' of copper turnings. Add moderately concentrated nitric acid, you will observe the reddish brown fumes of nitrogen dioxide near the mouth of the test tube. You will observe that the air column in the test tube from the reactants to the mouth of the test tube is colourless. The gas released by the action of moderately diluted nitric acid on copper is colourless nitric oxide. Nitric oxide when comes into contact with oxygen of the air forms reddish brown nitrogen dioxide gas.

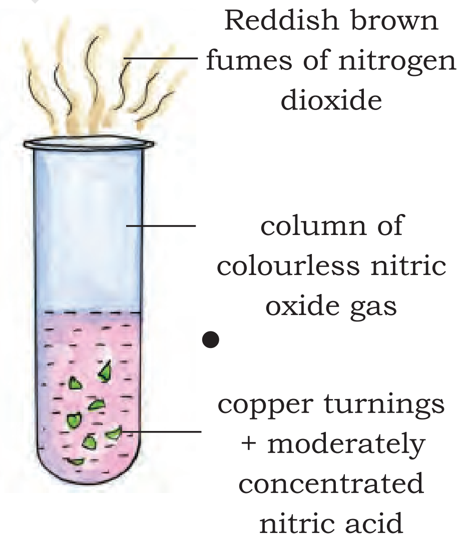

Reddish brown fumes of nitrogen dioxide
column of colourless nitric oxide gas
copper turnings + moderately concentrated nitric acid

Fig 15.3

$$2NO + O_2 \longrightarrow 2NO_2\uparrow$$

Activity 15.1

Visit a goldsmith's work place. Observe his method of purifying gold ornaments. Gold ornaments usually contain copper. When they are heated with dilute nitric acid, copper constituent of the ornament reacts with the acid forming greenish copper nitrate solution and reddish brown fumes of nitrogen dioxide. Gold remains unaffected. Can you give reason for this?

Know this

Very dilute nitric acid can easily react with the metals iron and aluminium. But if you dip an iron nail or a piece of aluminium wire in concentrated nitric acid taken in a beaker they do not react. The reason for this passivity of iron and aluminium in nitric acid is due to the formation of protective oxide layer on the metal instantly. Concentrated nitric acid is a powerful oxidising agent.

VIII. Displacement reactions of metals.

In 8th standard you have already studied about displacement reactions of metals. Recall the example

$$\underset{\text{(Aq)}}{CuSO_4} + Fe \longrightarrow \underset{\text{(Aq)}}{FeSO_4} + Cu$$

Name the reactants and products in this reaction. Explain the method of performing this experiment.

Reactivity series of metals. All metals are electro positive as they have a tendency to donate electrons and form positively charged ions, which are called cations. Some elements easily give up their valence electrons and hence more reactive. It is possible to arrange the metals in the decreasing order of their reactivity.

Know this

You know that cathode means negatively charged electrode. Anode means positively charged electrode. In the electrolytic process the positively charged ions are attracted by cathode and move towards cathode. Hence the positively charged ions are called cations. The negatively charged ions move towards anode and are called anions.

Exercise 15.4

Classify the following into cations and anions and represent them symbolically.

Eg: Calcium ion is cation. During the formation of chemical bond calcium atom, donates two electrons. Its symbol is Ca^{++}.

Eg: Chlorine ion is anion. During the formation of chemical bond chlorine atom receives one electron. Its symbol is Cl^{-}.

Represent the following symbollically

i) sodium ion ii) sulphide ion iii) Aluminium ion

iv) ferrous ion v) ferric ion vi) cupric ion vii) cuprous ion viii) Oxide ion.

Table : 15.2 Reactivity series of some metals.

Platinum Gold Silver Mercury Copper	Metals of this block do not displace hydrogen from dilute acids.
Hydrogen	Electro Positive
Lead	This metal displaces hydrogen, very slowly from the dilute acids.
Tin Nickel Iron	Metals of this block, displace hydrogen from dilute acids slowly
Zinc Aluminium Magnisim	Metals of this block displace hydrogen from dilute acids vigorously. But reaction will not be violent.
Sodium Potasium	Metals of this block liberate hydrogen from dilute acids violently and also react with water content of the acid vigorously.

Note that metals placed above hydrogen in the reactivity series do not displace hydrogen from dilute acids.

Occurence of metals in Nature : Stone age is gradually transformed into metal age when usage of metals became extensive. Role of iron in industrial renaissance is considered significant. When earth was formed most of the metals combined with nonmetals forming compounds. The metallic compounds which are not evenly distributed in the earth crust like the consituents of the air, occur in more concentrated quantity in certain geographical areas along with earthy impurities.

The compound of a metal from which the metal can be extracted economically is called ore.

Think it over

Almost all samples of the soil contains iron compounds to some extent. The compounds are absorbed by plants. Green vegetable leaves are good source of iron for our body. The Haemoglobin of our blood contains iron. Can you call the sources of food containing iron, haemoglobin of our blood as iron ores? Give reason. List metallic micronutrients required by our body.

Metals like gold and platinum are not chemically active. They do not form natural compounds. They occur in native or elemental form in Nature. Metals like copper and mercury though occur as compounds, in some places they occur in native form.

The following chart indicates the abundance of some common metals and non metals in the nature.

Know this

What is fools gold? Iron pyrites or Iron disulphide with a molecular formula of FeS_2 *resembles the lustre of metallic gold. It can be easily distingnished from gold by its brittle and hard nature.*

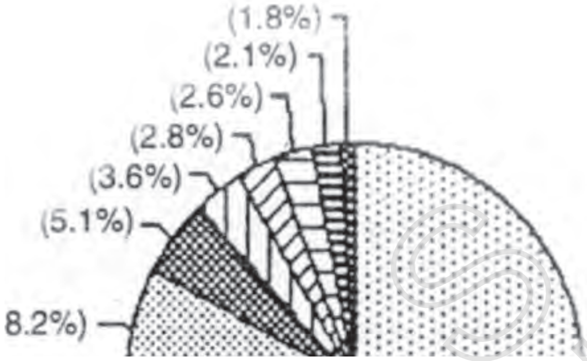


Fig. 15.4 Distribution of common elements in the earth's crust.

Ores can be oxides, sulphides, carbonates, chlorides, fluorides, or phosphates. **Example: Oxide Ores**: Bauxite, Haematite, Limonite, Magnetite and cuprite.

Sulphide ores : Copper glance, Copper pyrites or Chalcopyrites and Iron pyrites.

Carbonate ores : Siderite, Azurite, Malachite and lime stone.

Table 15.3 : Metallic ores of Karnataka

Sl. No.	Name of the metal	Name of the ore	Chemical composition	Place of occurence
1	Aluminium	Bauxite	$Al_2O_3.2H_2O$	Belgaum district
2	Iron	Haematite Magnetite	Fe_2O_3 Fe_3O_4	Bellary district Karwar district
3	Gold	Native form in quartz reef	—	Raichur district
4	Copper	Cholcopyrites or copperpyrites	$CuFeS_2$	Chitradurga District Raichur district
5	Manganese	Pyrolusite	MnO_2	Bellary district Karwar district Belgaum district
6	Chromium	Chromite	$FeOCr_2O_3$	Hassan district
7	Magnesium	Magnesite	$MgCO_3$	Mysore district

Metallurgy

The technology of extraction of metals from their ores and refining to the required form is called metallurgy. There are certain terms used in this technology. Let us know some of the terms and their meanings in brief.

1. Gangue

The unwanted earthly impurities present in the ore are called gangue particles.

2. Concentration of the Ore

When you bring a leafy vegetable from the market you separate the leaves from the stem and the roots and wash away the mud particles with water. By this process, you increase the desired component of the vegetable. In the same way the ore should be concentrated by removing unwanted impurities namely the gangue particles from the metallic compound and increase the percentage of desired component of the ore. Karnataka state exports the concerntrated ore of Iron from Mangalore port instead of directly mined ore. Why?

There are different methods of concentrating ore. It depends upon the differences in properties of the ore and the gangue particles.

Know this

Rice which is a staple food of Indians does not directly come to you from the plants. Paddy, Jowar, Wheat after harvesting are subjected to different processes to get the desired component. List the different techniques used by farmers to separate the food grains.

3. Roasting

Roasting is a process of heating the ore just below its melting point in the presence of air, Example : Zinc blende (ZnS) is roasted in the air to convert it into Zinc oxide (ZnO). Volatile arsenic compound impurities are also removed by roasting.

4. Calcination

Calcination is also a process of heating the ore just below its melting point in the absence of air with a purpose of driving away matter like water and carbon dioxide. Example : Oxide ores containing water vapour are calcined. Carbonate ores are calcined to drive away carbondioxide.

5. Flux

Flux is a substance that is added to the ores before heating with a purpose of removing certain unwanted impurities which are not removed during the concentration of ore. Flux combines with the impurities and form a compound called slag which can be removed easily because of its fluid nature. Selection of a flux depends upon the nature of the ore.

What are the principles of extracting the metal from its ore? The principles are based on the chemical reactions that you have studied earlier. Let us learn to prepare few metals in small quantity in the laboratary.

Activity 15.2

Preparation of copper *: Dissolve about 10 'g' of copper sulphate in water in a beaker. Immerse a thoroughly cleaned iron plate or iron nail in it. After few hours you will see the coating of copper on iron nail. If you leave it for 2 to 3 days you will observe copper granules on the iron plate / nail. This is based on the principle of displacement reaction. The principle was used in the earlier method of extraction of aluminium.*

Activity 15.3

Prepration of mercury *: In a hard glass test tube take a pinch of mercuric oxide (HgO). Heat the oxide slowly. After sometimes you will observe a beautiful mirror of mercury on the cooler part of the test tube. Recall that Joseph Priestly discovered oxygen by this technique.* $2HgO \xrightarrow{heat} 2Hg + O_2\uparrow$

This method is based on the principle of decomposition. [Caution : mercuric oxide is poisonous]

Activity 15.4

Preparation of silver *: If available in the laboratory take a small crystal of silver nitrate in a clean test tube. Remember that silver nitrate is expensive and take only a small crystal. Add distilled water to dissolve the crystal up to half of the test tube. Add one drop of ammonium hydroxide (Liquor ammonia) Add a pinch of glucose powder to the solution and gently warm the solution in a water bath. You can observe the coating of silver on the inner walls of the test tube. Instead of glucose you can use freshly prepared ferrous sulphate solution.*

Aldehyde group in glucose or Ferrous sulphate solution reduces silver nitrate to metallic silver.

The art of metallurgy though based on chemical reactions, is not as simple as stated in the above activities. Often it involves complicated processes. Over a period of time,. the art is perfected to get high quality metal. We shall study about the extraction of Iron and the extraction of aluminium, two metals which are widely used metals in our daily life.

Extraction of Iron

Concentration of Haematite : The most common Ore of Iron that is found in Karnataka state is Haematite. It occurs with impurities such as clay and silicon dioxide or silica. The ore is concentrated by a process called hydraulic washing. The crushed ore when washed with stream of water, lighter impurities will be washed away. Heavy iron ore particles along with silica setlle down during washing.

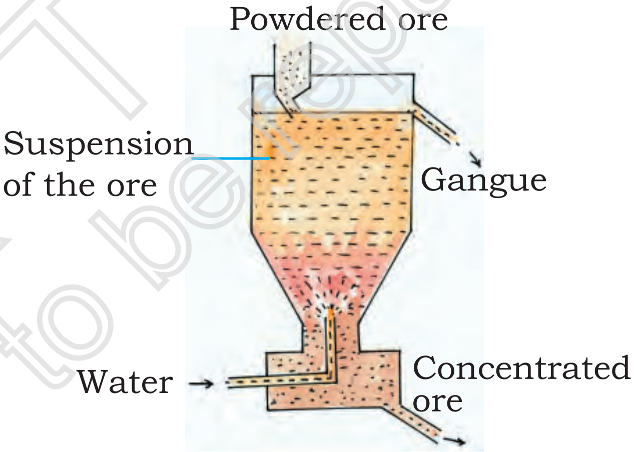


fig. 15.5 Hydraulic Washing

Exercise 15.5

Collect information about the methods of concentrating ores like magnetic separation and froth floatation method. Find the names of the ores concentrated by these methods.

Calcined Iron ore is sent to the blast furnace by mixing it with limestone, which is flux in this case and coke, which is a cheaper reducing agent. The quantity of flux depends upon the quantity of Silica present in the ore. Iron ore is graded on the basis of the percentage of haematite and silica.

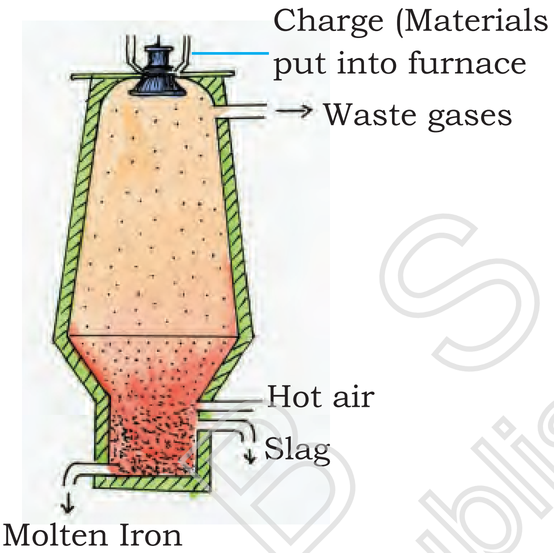


fig. 15.6 Blast furnace used in the extraction of iron

A blast of hot air is sent through the mixture of haematite, limestone and coke. The main chemical reactions that take place in the furnace are given below.

I. i) Limestone $\xrightarrow{\text{heat}}$ Quicklime or calcium oxide + Carbon dioxide

$CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2\uparrow$

ii) Calcium Oxide +Silica $\longrightarrow$ Calcium silicate (slag)

$CaO + SiO_2 \longrightarrow CaSiO_3$

Lime stone helps in the removal of silica from the ore in the form of calcium silicate slag.

II. Carbon + Oxygen $\longrightarrow$ Carbon monoxide (In the blast furnace due to the limited supply of oxygen carbon monoxide is formed instead of carbon dioxide)

$2C + O_2 \longrightarrow 2CO\uparrow$

Haematite + Carbon monoxide $\longrightarrow$ Molten iron + Carbon dioxide

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2\uparrow$

Coke helps to reduce the oxide of iron to iron. Slag is lighter than molten iron and collects on the molten iron. Slag prevents the oxidation of molten iron back into oxides of iron. The molten iron is converted into solid blocks called **pigs**.

Know this

Slag obtained in the blast furnance is one of the ingredients of glass and cement. Can you name the other ingredients of glass and cement?

The pig iron obtained from the blast furnace is also called cast iron. It contains impurities like sulphur, phosphorus, silicon and carbon. It will be hard and slightly brittle. It can be used for making stands for wooden benches and desks. It can also be used to make Dosa pan and as a lid for covering manholes of sewage system, and machinery spare parts.

The impurities present in the blast furnace can be removed by Bessemer converter, Open hearth process or by Electric furnace to make different types of steel.

Extraction of aluminium

In the history of civilisation, there is mentioning of gold, silver, copper, tin, lead, iron and mercury. These metals were known to ancient people Gradually metals like magnesium, calcium, nickel, chromium were added to the list. Periodic table prepared by Mendeleev also helped in the discovery of new elements most of which were metals. Aluminium is a 19th century metal. Now it is extensively used and popularly known as poor man's silver.

Know this

Aluminium is the third most abundant element after oxygen and silicon. Earlier the element was not known. But aluminium salts were used for different purposes. They were used as mordant in textile dying. Mordant is a substance which helps to bind the dye to the cloth. Potash alum is used even to day as aseptic to prevent bleeding from small cuts by coagulating the blood at the surface.

History of aluminium : We hesitate to throw away even a pin or iron nail, though it is cheaper. When iron rusts iron is not wasted. It is present in the form of iron oxide. But we do not return it to its original place. It becomes a waste and it is not possible to recycle or get back iron. But without thinking much we throw away chocolate wrappers, tablet covers which are made from aluminium. Aluminium is such a cheap metal today that anybody can afford it.

Aluminium was more expensive than gold about 150 years ago. Aluminium was used in the toys and jewelleries of the royal families only.

Note

It is better to use utensils made from aluminium alloys than pure aluminium for longevity of vessels.

Commercial production of aluminium was done by Herri-sainte -claire -Deville in Paris in 1854. In 1855 small bars of aluminium were exhibited at Paris exhibition alongside the crown Jewels of France.

Humphry Davy in 1807 identified the presence of aluminium in alum. He called it alumium. Hans Christian Oersted discovered it first by heating aluminium chloride with potassium amalgam. It was confirmed in 1827 by Friedrich Wohler and he is credited as isolator of aluminium.

$$AlCl_3 + 3K \xrightarrow{heat} 3KCl + Al$$

Today aluminium has changed our life style. It is due to its abundance and the method of isolating aluminium on large scale by the process of electrolysis.

Paul L. T. Heroult

Paul.L.T. Heroult 1863-1914

Paul Heroult was a French scientist. He read about the research papers on aluminium, when he was fifteen years old. He succeeded in extracting aluminium from bauxite by electrolysis in the year 1886 when he was 23 years old. His second most important invention was electric arc furnace for manufacturing steel. Though he did not have attributes of a traditional scholar, his inventions were the result of common sense and genius.

Charles Martin Hall 1863-1914

Charles Martin Hall

Charles Martin Hall was an American inventor and Chemist. At the age of six, he started reading his Father's Chemistry book. He was inspired by his professor's remark, " He would be a great chemist and would do good to humanity, who would be able to devise a method of extracting aluminium from clay----". Martin Hall is well known for inventing the method of extracting aluminium in the year 1886. Most of his inventions are related to aluminium and its alloys.

The important ore of aluminium is bauxite which contains hydrated oxide of aluminium which is also called alumina. Its molecular formula is $Al_2O_3.2H_2O$. Remember that haematite also is ferric oxide with molecular formula Fe_2O_3. The oxygen of ferric oxide can be easily taken away by reducing agent like coke. But oxygen of aluminium oxide can not be easily taken away by reducing agents like coke, as aluminium has greater affinity towards oxygen. However reducing agent like potassium metal can yield aluminium which is not commercially viable.

$$Al_2O_3 + 6K \longrightarrow 3K_2O + 2Al$$

Aluminium is extracted by Hall-Heroult method of electrolysis on a very large scale.

For electrolysis we need pure alumina. For this reason bauxite is concentrated by chemical process to get pure alumina.[Aluminium oxide]

Powdered bauxite is dissolved in hot sodium hydroxide solution to get a solution of sodium aluminate. The gangue particles are filtered out.

$$Al_2O_3 + 2NaOH \rightarrow 2Na\,AlO_2 + H_2O$$

(This reaction shows the amphoteric nature of aluminium oxide)

By passing carbon dioxide through the filtrate a gel like precipitate of aluminium hydroxide is obtained.

$$2NaAlO_2 + CO_2 + 3H_2O \rightarrow \downarrow 2Al\,(OH)_3 + Na_2CO_3$$

Sodium carbonate is separated by filtration. The precipitate of aluminium hydroxide is heated to get pure alumina.

$$2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$$

Pure alumina melts at 2323 K. It consumes more energy and more over molten alumina is not a very good conductor. If it is electrolysed at that temperature, most of the aluminium evaporates and there will be considerable loss. But when mixed with molten cryolite alumina forms an electrolyte at 1223 K only. Molten cryolite also acts as a solvent for alumina. In this way high temperature electrolysis can be avoided. Cryolite is chemically sodium aluminium fluoride with a molecular formula of Na_3AlF_6.

Aluminium oxide is dissolved in molten cryolite and taken in a chamber with gently sloped base. Graphite rods are introduced in the electrolytic bath. The inner wall of the electrolytic chamber is made up of carbon lining. Carbon lining is connected to the cathode and graphite rods are connected to the anode. When a strong source of direct current is passed, molten aluminium collects at the lining and flows out of the gently sloped base.

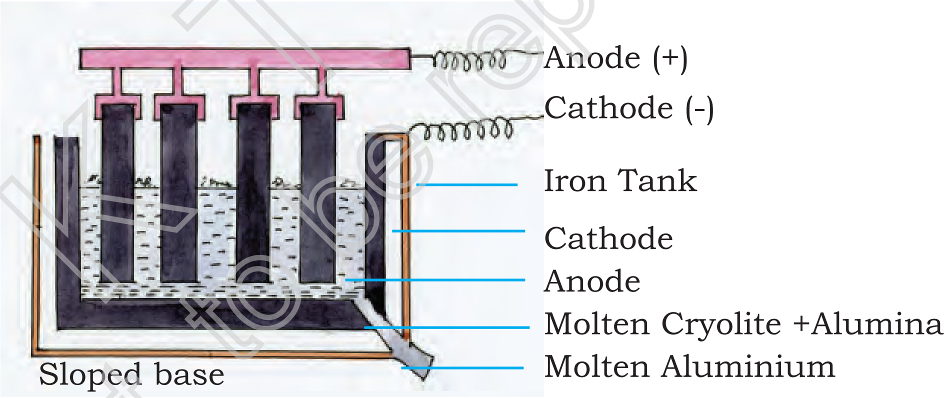


Fig. 15.7 Extraction of aluminium from alumina

Know this

Aluminium is electropositive and hence collects at the cathode. What might be the products of the above process at the anode? The electrolytic bath contains, in addition, oxygen, fluorine and sodium ions also. Oxygen is liberated at the anode. Due to high temperature oxygen may combine with anode forming small quantities of carbon monoxide and carbon dioxide. Sodium and fluorine are highly reactive and remain in the combined state by quick dissociation and association.

Metals obtained by electrolysis are normally pure. To obtain ultra pure metal by removing traces of other metals and salts, it can be further purified by different methods. The methods of obtaining ultra pure metals are,

1. Fractional crystallisation or zone refining
2. Vacuum melting
3. Distillation
4. Chemical vapour deposition
5. Liquation process

We shall study three methods of refining metals namely Liquation process, Zone refining and Electrolytic refining.

Liquation process : Liquation process is based on the fact that certain metals are readily fusible where as the impurities are infusible at the temperature at which the metals fuse.

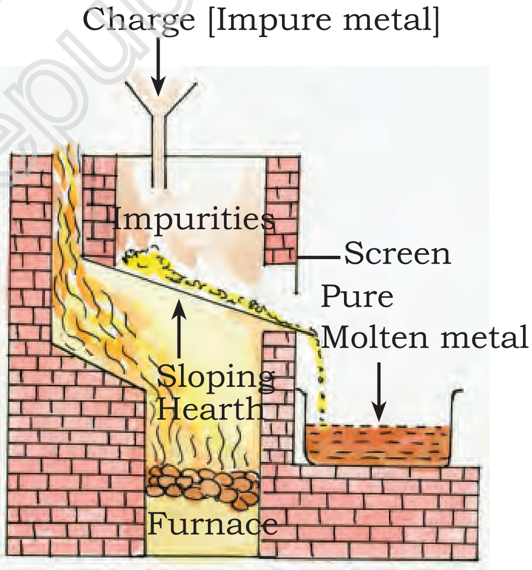


Fig. 15.8 Liquation process

Zone refining or fractional crystallisation : Zone refining technique is based on the principle of differences in solubility of impurities in liquid and solid states of the metal. A circular heater is fitted around the rod of impure metal at one end and is slowly moved to the other end. At the heated zone, the rod melts and as the heater passes on, pure metal crystallises and imprities insoluble in solid metal pass into the adjacent molten part. Impurites are swept into one end of the road and finally discarded. The process is repeated. Germanium is purified by this method.

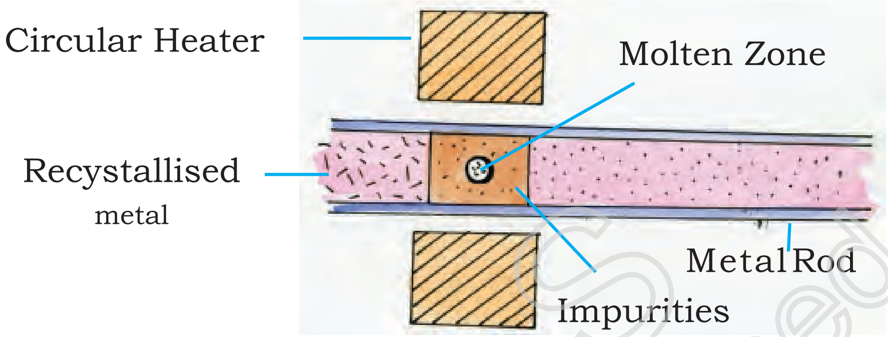


Fig. 15.9 Zone refining

(Heater will be in the form of a bangle around the rod of impure metal)

Electrolytic refining.

Copper, gold, silver are refined by this technique. Electrolytic bath contains the metallic ions of the metal to be purified. Pure thin sheet of the metal is made cathode. Impure metallic plate is made the anode. When direct current is passed, pure metal collects at the cathode. Impurities remain at the bottom near anode, which is called anode smudge.

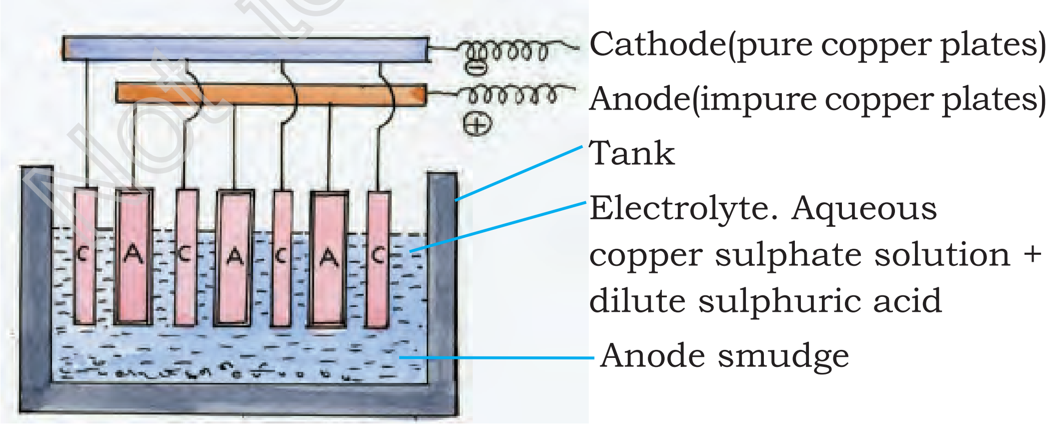

Cathode(pure copper plates)
Anode(impure copper plates)
Tank
Electrolyte. Aqueous copper sulphate solution + dilute sulphuric acid
Anode smudge
C
A
C
A
C
A
C

Fig 15.10 Electrolytic refining of Copper

Alloys

Alloy is a homogeneous mixture of two or more metals in suitable proportion. Sometimes nonmetals like carbon, silicon are also used to make alloys. Alloy gives desirable properties to the metal. In fact we generally use alloys instead of pure metals. For example pure gold is too soft to make ornaments with artistic design and patterns. Addition of small quantity of copper to it makes it hard and improves the look and the colour. Ornamental gold is an alloy. Iron nails, pins pipes are made from the alloy mild steel and not from pure iron.

Think

Is preparation of an alloy physical change or chemical change? It is debatable.

Know this

Is an alloy a compound or mixture? It depends on the alloy and its constituents. The constituents of an alloy can be mixed in different proportions. In some cases law of definite proportions can not be applied rigidly. Alloy can not be assigned a definite molecular formula. But if you call it a mixture properties of the constituents of the mixture may not be a totallity of properties of some constituents. Copper is reddish and zinc is greyish in colour. Where as brass, which is an alloy of copper and zinc is golden yellow in colour. A good quality stainless steel is not magnetic inspite of the presence of magnetic substances in it. Study of bond formation in alloys and development of new alloys is an area of scientific research.

Know this

In modern days better quality alloys can be made by mixing metals using ultrasonics. Metals belonging to the same group in the periodic table form good quality alloys because of similarities in electronic configuration. Ancient Indians made alloys by mixing metals which have more or less high melting point and which can mix with each other easily.

In the following table a list of commonly used alloys, their constituents and uses are given.

Table No. 15.4 Commonly used alloys.

Sl. No.	Name of the alloy	Constituents	Uses
1	Stainless steel	Iron + Carbon + Chromium + Nickel	Surgical instruments, utensils. It is not attacked by mild chemicals easily.
2	Invar	Iron + Carbon + Nickel (large quantity)	It is used in precision measuring tapes as it has least coefficient of linear expansion.
3	Nickel steel	Iron + Carbon +Nickel (small quantity)	Used to make machinery parts.
4	Brass	Copper + Zinc	Electrical contact parts. Utensils and decorative articles.
5	Bronze	Copper + Zinc + Tin	Statues, medals, utensils
6	Duralumin	Aluminium + Copper + Magnesium + Manganese.	Aeroplane body, railway coaches, bus coaches
7	Alnico	Nickel +cobalt + Iron +Aluminium	Permanent magnets

Contribution of Indians to the metallurgy

The Romans used armour and cutlery made from Indian Iron. The Indian metallurgist Nagarjuna wrote a book 'Rasaratnakara' around the 9th century BC which explains the preparation of various metallic compounds, the extraction and purification of metals.

Indians were first to develop the methods of extracting zinc and using it in alloys.

The famous iron pillar at New Delhi near Kutubminar was constructed by Vikramadithya almost 1600 years ago. This is an excellent example of an alloy of iron which can withstand the action of weather. There are many such wonderful artefacts spread all over the country. The creativity and highest degree of skill level of Indian craftsmen are appreciated by all.

The world famous Bidri art is the skill of producing artefacts of ornamental value. The very name is derived from 'BIDAR' a district of Karnataka state.

Bidar has a special clay, with which the mould can be prepared and the mould thus prepared will not lose its shape on heating. Even to day the technology is practised and needs encouragement as the technology is endangered.

Karnataka in ancient times is known for valour and the skill of war. Many epitomes (Veeragallu) found in Karnataka are evidences for this. This also suggests that Karnataka had many mines of metals and people were well versed in metallurgy and armoury.

Bidri art is depicted in some of the following pictures.

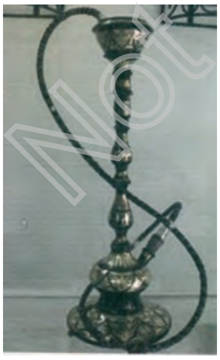


Fig 15.11
Hukka

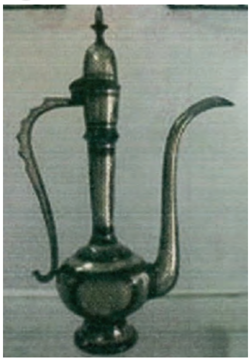


Fig 15.12
Bidari wine decanter

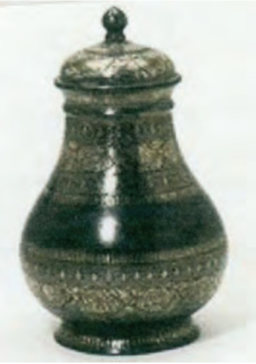


Fig 15.13
Jar with lid

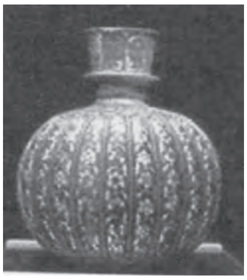


Fig 15.14
Jar

Illustrations of contribution of Indians to Metallurgy.

15.15 Coin of Chandra Gupta II 375 - 415 CE at British Museum

15.16 Standing idol of Buddha 7th Century AD. Origin Eastern India. Now in Birmingham Museum

15.17 Vijaya stambha at Delhi

15.18 Idol of Lord Nataraja

15.19 Bronze idol of Buddha

15.20 The artefacts prepared by the ancient Indian skilled workers.

Know this

Amazing alloys : Memory alloy : There are certain alloys when deformed gain their original shape. The articles made out of these alloys when twisted or squeezed or physically deformed and kept aside, regain their original shape after sometimes. Preparation of such alloys saves energy of melting and recasting of used articles. From the internet find out the constituents of one such memory alloy.

Exercise

I. Four alternatives are given to each of the following statement or question, select the most appropriate answer

1. The following is a metal in liquid state at room temperature.

   a. Bromine b. Mercury c. Germanium d. Silicon

2. The following element forms cations,

   a. Sulphur b. Graphite c. Manganese d. Iodine

3. The oxide that can form salt and water with a base as well as with an acid is,

   a. Carbon monoxide b. Sulphur dioxide

   c. Sodium oxide d. Aluminium oxide

4. Electron donor among the following is,

   a. Potassium b. Phosphorus

   c. Oxygen d. Fluorine

5. Hydrogen gas is liberated under the following circumstance.

   a. Iron kept in boiling water

   b. Water is poured on hot iron

   c. Steam is passed over red hot iron

   d. Iron is immersed in cold water

6. The metal that cannot liberate hydrogen with dilute acids is,

   a. Sodium b. Aluminium c. Copper d. Potassium

7. Lemon juice is served normally in ceramics or glass tumblers instead of metallic tumblers because,

   a. glass and ceramics are cheaper

   b. metallic containers react with the acids of lemon

   c. lemon juice produces combustible hydrogen gas with metallic tumblers

   d. glass and ceramics keep the lemon juice cooler

8. The following combination of metal and acid liberate sulphur dioxide

   a. Zinc and dilute Nitric acid

   b. Zinc and dilute Sulphuric aid

   c. Zinc and Hydrochloric acid

   d. Zinc and concentrated Sulphuric acid.

II. Fill in the blanks

1. $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + 2H_2O$ + --------------
2. $2Na + 2H_2O \longrightarrow 2NaOH$ + ----------------
3. The alloy that has least coeficient of linear expansion is ________
4. Germanium is purified by the technique -------------
5. Reducing agent used in the extraction of iron is ------------

III. State whether the following statements are true or false

1. Gold occurs in native form.
2. Sodium is always found in compound state.
3. Mercury can displace hydrogen from dilute acids.
4. Ornamental gold is not an alloy.
5. Iron becomes passive when immersed in concentrated nitric acid.

IV. Math the following

A	**B**
1. Haematite	a. Chloride
2. Copper pyrites	b. Phosphate
3. Limestone	c. Oxide
4. Common salt	d. Sulphide
	e. Carbonate
	f. Fluoride
	g. Nitrate

V. Give reasons for the following

1. Magnesium ribbon should not be kept near bottles containing volatile chemicals.
2. Aluminium becomes passive when dipped in concentrated nitric acid.
3. Limestone and Coke are used in the extraction of Iron from Haematite.
4. Nitric acid is not normally used to prepare hydrogen gas in the laboratory.
5. Aluminium can not be extracted by heating bauxite and coke.
6. Tin is used to coat the inner walls of brass and copper utensils.

VI. Answer the following

1. Name any two ores of Iron.
2. Name the constituents of the alloy stainless steel.
3. Name any three methods of refining a metal.
4. Write a neat diagram of blast furnace and label the parts.
5. Write balanced equation of the reaction taking place between copper and moderately concentrated nitric acid when heated.
6. Draw a neat diagram of the apparatus used in the extraction of aluminium from bauxite and label the parts.

CHAPTER 16

ELECTRO MAGNETIC INDUCTION

After studying this chapter you

- recall the experiment of magnetic effect of electric current.
- give examples for sources of electricity.
- state the advantage of electricity as a source of energy over the other sources such as fossil fuels.
- state Faraday's laws of electromagnetic induction.
- state the factors on which induced emf depends.
- explain the working of A.C and D.C dynamos.
- draw neat diagrams of A.C. and D.C dynamos.
- distinguish between A.C and D.C
- explain the working of D.C motor.
- state the principle of induction coil and transformers.
- draw a neat diagram of D.C motor.
- state Fleming's right hand rule and left hand rule.
- recognise the importance of transformers.
- appreciate the contribution of Faraday to mankind.
- prepare models of dynamo and motor.
- develop skill to use toy D.C motor to prepare model of a D.C dynamo.

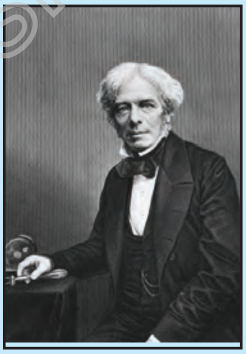
You are familiar with the various sources of energy. Apart from solar energy, we depend upon fossil fuels like coal and petroleum. The role of fossil fuels in industrial renaissance (revolution) is most significant. Coal and petroleum products were used to produce heat energy and heat energy was converted into mechanical energy. Though there was knowledge of electricity as a form of energy in earlier days, its production on a large scale was yet to be invented. Chemicals were used to produce electricity on a small scale. You are familiar with such type of sources of electricity like acid batteries and alkaline cells.

The experiment of electromagnetic induction changed the entire scene. The experiment helped to think of devices which can produce electricity on small scale and large scale by using mechanical energy.

What is electromagnetic induction? Who conducted this experiment? What are the results of the experiment? What are the practical applications of electromagnetic induction? We shall learn about these things in this lesson.

Michael Faraday 22 September 1791 - 25 August 1867

Brief biography of Michael Faraday


Michael Faraday

It is really a remarkable achievement of a book binder who joined as assistant to Humphry Davy of Royal Society of Landon, who rose to the level of presidentship of Royal society of London, and of course he declined the offer of presidentship. He received little formal education. He was a self taught person. While working as book binder, he read many books on science. He attended science lectures of Humphry Davy.

Experiments, systematic documentation and drawing conclusions on the basis of observations helped in the discovery of benzene and new compounds of chlorine. The present day bunsen burner used in the school and college laboratories was invented by Faraday in a trivial form. The greatest contributions of Michael Faraday are: Faraday's laws of electromagnetic induction, Faraday's laws of electrolysis. He introduced oxidation numbers and popularised terminology such as anode, cathode, electrode and ion. SI unit of capacitance 'farad' is named in his honour. Citing ethical reasons he refused to offer his services to the British government in the preparation of Chemical Weapons.

In your previous class you have studied about the effects of electricity. Magnetic field is produced around a conductor carrying electric current. (Oersted's experiment) made, Michael Faraday to think about the possibility of a reverse effect. If electricity can produce magnetism around a conductor, can a magnet produce electric current in a conductor? He did some experiments to check his line of thinking and was successful in producing electric current using a magnet. Thus, Electro magnetic induction was discovered. Let us conduct similar experiment conducted by Michael Faraday.

Activity 16.1

Take a card board tube of about 3 to 4 cm diameter from a discarded incense stick pack. Wind a metre long enamelled copper wire on the pipe. Refer figure number 16.1. You can get enamelled wire from a motor winding shop or from a mixer grinder repairer shop or from a second hand transformer. Scrap the enamel at the ends of the wire and connect the loose ends of the wire to a galvanometer. If a galvanometer is not available you can make a simple compass needle galvanometer. Refer to the extended activities No. 16.5 at the end of the chapter.

Take a bar magnet and push it inside the tube while observing the needle of the galvanometer. What do you observe? Take the magnet out. What do you observe? Continuously move the magnet inside and outside the tube. What do you observe? Repeat the experiment by keeping magnet stationary and making the coil to move. Repeat the experiment by changing the number of turns of the coil. Repeat the experiment by increasing the speed of the movement of the coil. Record your observations in a table.

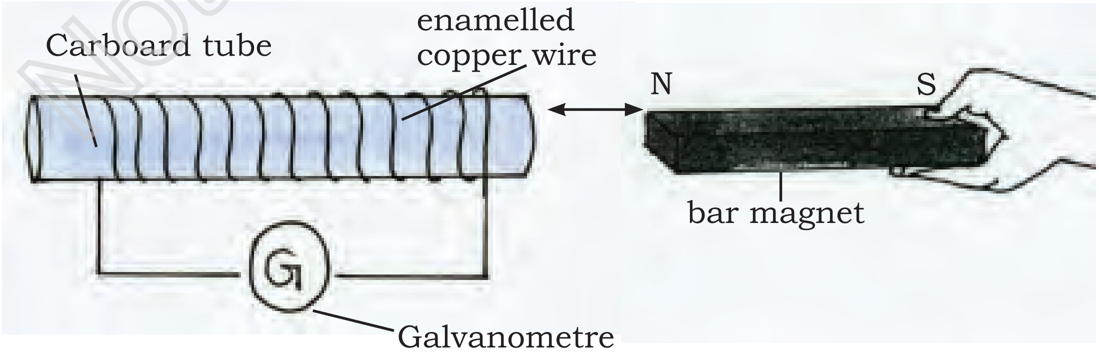


Fig. 16.1 Experiment to demonstrate the production of induced e. m. f.

Note these wonders

1. Flow of electric current takes place without a battery.
2. A magnet from a distance can cause electrons to move in a specific direction.
3. Direction of current depends upon the direction of motion of the magnet.
4. It also depends upon the nature of pole that is introduced in to the coil and removed from the coil.

Table No. 16.2

Sl. No.	Experiment	Observation	Inference
1	Magnet is pushed into the coil	Galvanometer shows deflection.	E. M. F is induced in the coil.
2	Magnet is taken out of the coil	Galvanometer shows a deflection in opposite side.	E. M. F is induced in the coil. but flow of the current is in opposite direction.
3	Magnet and the coil remain stationary	Galvanometer does not show any defection	Induced E. M. F is not produced.
4	The number of the turns of the coil is decreased and the magnet is pushed inside the coil	Galvanometer shows comparatively lesser degree of deflection	The magnitude of the induced current depends upon the number of turns.
5	The magnet is pushed inside the coil very quickly.	Galvanometer deflection will be large.	Magnitude of the induced E. M. F depends upon the speed of the magnet.

From the above experiments Michael Faraday concluded that the strength of the induced e.m.f depends on

i) the number of turns of the coil
ii) the strength of the magnetic field
iii) the speed with which the magnet or the coil moves
iv) area of the coil.

On the basis of these results Faraday enunciated two laws.

Faraday's laws of electromagnetic induction

I law : Whenever a magnetic field linked with a conductor changes, an induced e.m.f. is generated in the conductor.

II law : The magnitude of induced emf is directly proportional to the rate of change of magnetic field linked with the conductor.

> **Note :** Induced current is produced in a straight conductor also when it moves in a magnetic field.

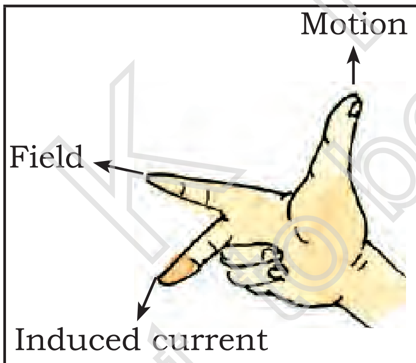


Fig. 16.2
Fleming's Right hand rule

Direction of motion of the conductor - Thumb

Direction of magnetic field - Fore finger

Direction of electric current - Middle finger

Direction of the induced emf is given by **Fleming's right hand rule**. Arrange the first three fingers of your right hand mutually perpendicular to each other, as shown in the figure number 16.2. If the fore finger indicates the direction of the magnetic field, the thumb the direction of motion of the conductor, then the middle finger will indicate the direction of the induced emf.

This rule is useful to decide the direction of the current since other two parameters are known.

Alternating Current

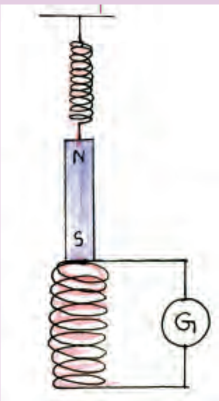


Fig. 16.3
Alternating current

Activity 16.2

Suspend a bar magnet from the down end of a spring into a coil of a conductor as shown in figure no 16.3 and connect ends of the coil to a galvanometer. Pull the spring and release. This sets the magnet into vertical oscillations and hence it moves into the coil and comes out alternately. Observe the needle of the galvanometer. The needle oscillates about the 'O' mark alternately indicating that the direction of the current changes twice during one complete vertical oscillation. (Up and down)

Alternating current is that which changes its direction, to and fro periodically. The electric current we get in our homes is alternating. It alternates 50 times each second. We say that the frequency of the A.C supply is 50 Hz or 50 cycles per second. The domestic voltage of A.C is about 230 volts. There may be fluctuations. To protect the expensive electrical appliances from high voltage, stablisers are used. A.C.e.m.f. or voltage can be converted into D.C. voltage using electronic device called rectifier. Graphical representation of alternating current is as shown.

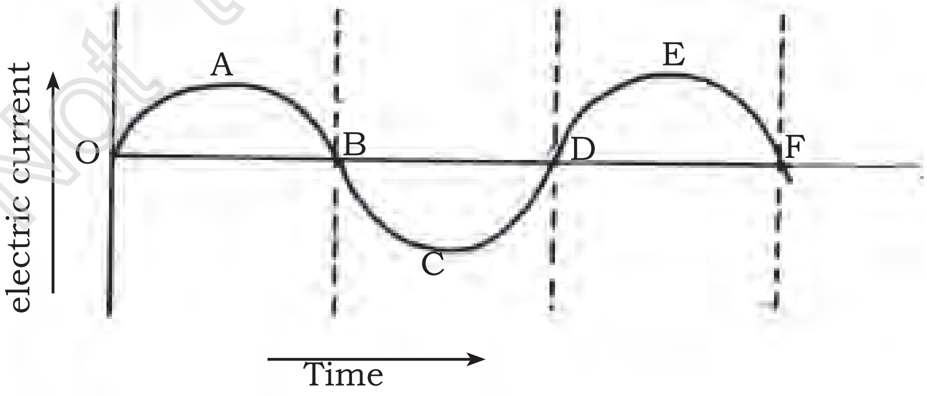


Fig. 16.4 Graphical representation of alternating current

A,C,E are the points of maximum current.
O,B,D,F are the points of Zero current.

Applications of electromagnetic induction

There are mainly three popular devices which work on the principle of electromagnetic induction.

1) A.C. and D.C. Dynamo.

   Huge dynamos used in hydroelectric power or thermal power stations or nuclear reactors are usually referred to as generators.

2) Transformers : Transformers are used to increase or decrease the voltage.

3) Induction coil : It is used to obtain high D.C. voltage from a low voltage D.C source.

   Dynamo is a device which converts mechanical energy into electrical energy by the principle of electromagnetic induction.

Activity 16.3

Go to nearby bicycle shop and observe how a dynamo fixed to rear wheel of cycle produces current.

A.C dynamo consists of

i) an armature which is a rectangular coil of insulated wire ABCD wound over a core of soft iron. The core is not shown in the figure.

ii) slip rings R_1, R_2

iii) brushes B_1, B_2

iv) permanent magnet N,S. (Refer fig no. 16.6)

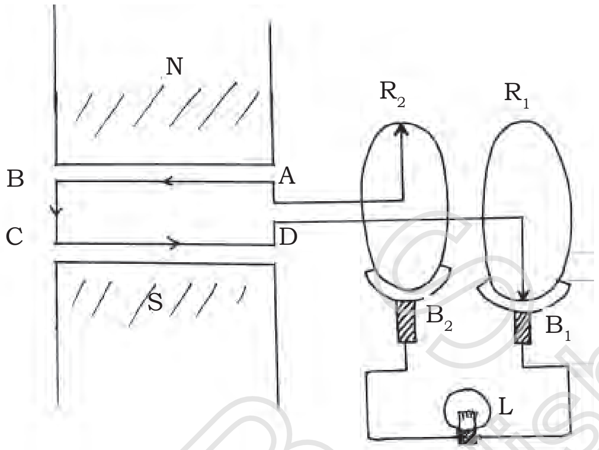


Fig. 16.5 AC Dynamo

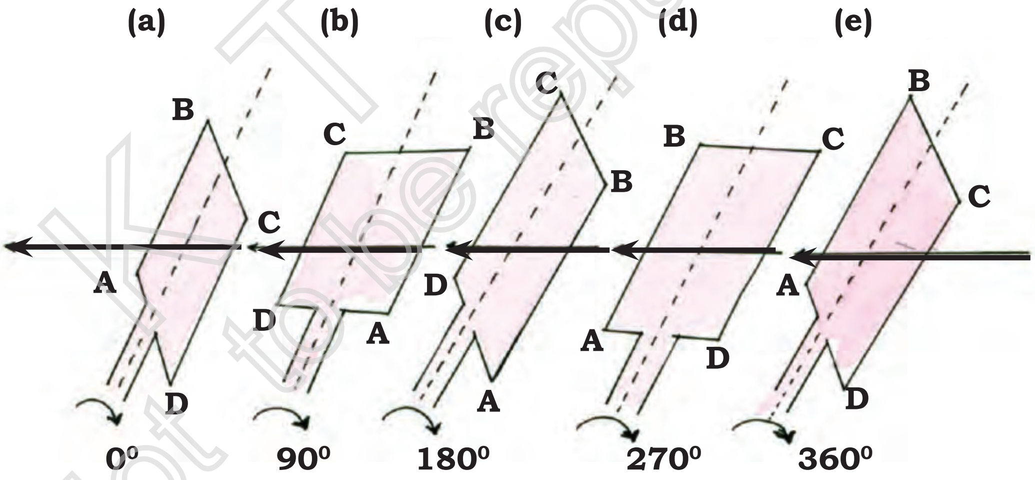


Fig. 16.6 Different positions of the rotating coil of AC dynamo in the magnetic field

The ends of the armature coil are soldered to the two slip rings. The slip rings press against the carbon brushes and the carbon brushes are connected to the external circuit (Lamp L). The armature is mounted between the poles of a powerful magnet. The armature coil is rotated mechanically. As the coil rotates there will be an induced current in the coil ABCD. This will light up the bulb L. The magnitude of induced current will be different at different locations of the coil. (fig 16.6) According to Fleming's right hand rule the current moves in the direction of ABCD during the first half of the rotation. During the second half of the rotation the current moves in the direction of DCBA. The current in the external circuit therefore flows in one direction for one half cycle and in the opposite direction for the second half cycle. It is therefore an alternating current. (Refer fig. no. 16.5). The dynamo is called alternating current dynamo. The frequency of the alternating current is the same as the frequency with which armature rotates.

Know this

In a bicycle dynamo, the friction between moving tyre and the cylindrical head of the armature makes the armature to rotate. In hydroelectric power stations the turbines rotate by flow of water. The rotation of the turbines are transferred to the armature heads of the dynamos.

In nuclear power reactors or thermal power stations the turbines rotate by the flow of steam. In windmills the small turbines rotate by the force of wind. Ultimately dynamo produces electric current.

Alternating current is used for domestic supply. The voltage range of domestic AC is 230-250 volts.

Main uses of alternating current.

1. Domestic appliances like lamps, heaters, fans, ovens, radio etc. require A.C. (Alternating current).

2. To produce required frequency radio waves for Radio, T.V transmission, RADAR and wireless communication AC current is used. Remember the work of Shri Jagadeesh Chandra Bose in this regard. (Refer the chapter 'Communication' of 8th standard science text book)

3. Alternating current is used to produce ultrasonics which have applications in the field of

   i) Industries

   ii) Medical diagnosis by ultra sound scanning

   iii) SONAR : to detect the underwater objects.

Know this

In A.C. dynamo the magnitude of the induced current varies from zero to maximum as the plane of the coil becomes perpendicular to the direction of magnetic field and again becomes zero as the plane of the coil becomes parallel to the magnetic field. Again varies from zero to maximum in the opposite direction, when the plane of the coil is again perpendicular to the direction of magnetic field, the cycle repeats.

DC dynamo

i) S N Magnetic poles
ii) ABCD coil on armature
iii) B_1 , B_2 Brushes
iv) S_1, S_2 split rings
v) L lamp.

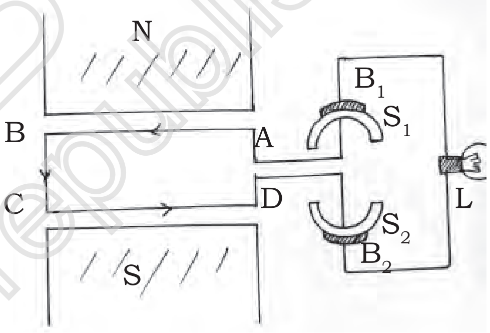


Fig. 16.7 D.C Dynamo

A dynamo in which the induced current is always flowing in one direction is called a direct current dynamo or DC dynamo. The slip rings used in the A.C. dynamo are suitably modified for this purpose. We use a split rings. (Two half rings) The two brushes B_1 and B_2 make press contact with the two halves of the split rings S_1 S_2. (fig no 16.7) During the first half rotation of the coil the split ring S_1 presses against the brush B_1 and S_2 against B_2. During the second half S_1 press B_2 and S_2 presses B_1. This action of the commutator split rings reverses the connection to the external circuit. Instead of the current reversing the current continues to flow in the same direction. During the first half the current flows along ABCD in the coil and along B_2 L B_1 in the external circuit. In the second half also, the current is along DCBA in the coil but along B_2 L B_1 in the external circuit. But the magnitude of the current is not constant. It starts from zero reaches maximum, again reaches zero. The cycle repeats in the same direction. The graph of electric current in the external circuit of a DC dynamo is given in the figure no. 16.8.

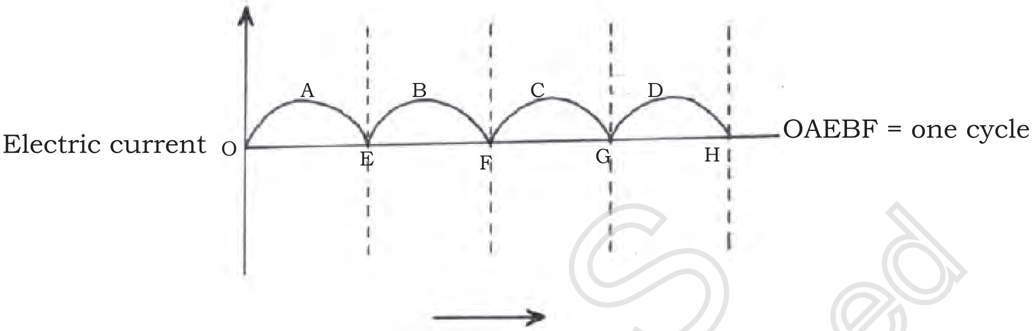


Fig. 16.8 D. C. Flow

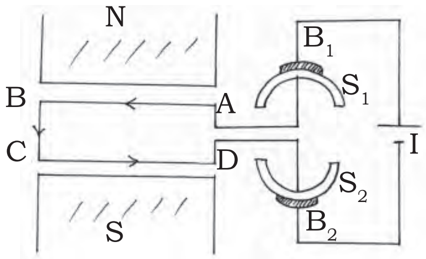
Do you know ?

What should be the type of source of electric current to get electric current of constant magnitude? What is an adapter or battery eliminator?

A.C can not be used for electrolysis. Why?

DC Motor

Motor is a device which converts electrical energy into mechanical energy. In a DC dynamo instead of a lamp if a direct source of suitable voltage is substituted what happens? Can you imagine? Your imagination may be correct. The coil starts rotating. A motor works on the principle that, “a conductor carrying electrical current experiences mechanical force if kept in a magnetic field”. This principle is also known as motor rule. DC Motors are used in toys.

i) NS magnetic poles ii) ABCD coil on armature iii) B_1 , B_2 brushes iv) S_1, S_2 split rings v) I-D.C source	 N B_1 S_1 B A C D I S_2 B_2 S Fig. 16.10 DC Motor

By referring to figure no 16.10 can you explain the construction of a DC motor? You can explain it on the basis of the explanation given in the construction of AC and DC dynamo. What will be the direction of movement of the conductor or coil? It is given by Fleming's left hand rule. Arrange the first three fingers of your left hand mutually perpendicular to each other. If the fore finger indicates the direction of the magnetic field, the middle finger indicates the direction of the electric current, then the direction of the motion of the conductor is given by the main finger or thumb. Refer figure no. 16.11

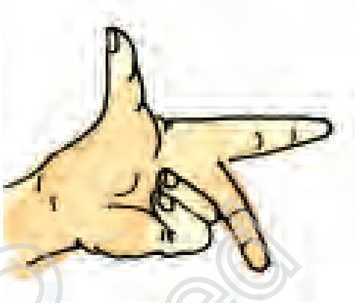


Fig. 16.11
Left hand roule

Activity 16.4

Suspend a straight conductor in the form of aluminium rod using two thin copper wires connected to a D.C source as shown in the figure no.16.9 Keep a strong horse shoe magnet such that the conductor is in between the poles. When the current flows in the circuit, the conductor deflects. If the direction of the current is reversed the deflection of the conductor is also reversed. DC motor works on the principle of observation of this activity.

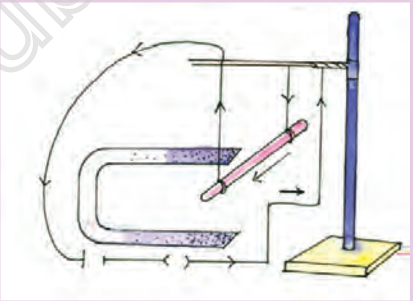


Fig. 16.9 Motor force

AC Motor

Fans, mixer, grinder, washing machines work on AC source. AC motors contain electromagnets and commutator to reverse the direction of the current and magnetic field simultaneously for every half rotation of the armature. The armature continues to rotate in the same direction though the source of the electric current regularly changes its direction.

Activity 16.5

Classify the following into devices that use high voltage and low voltage electric current.

i) Radio transistor receiver set.
ii) Television receiver set
iii) cathode ray discharge tube
iv) small night lamps
v) tape recorder.

Other applications of electromagnetic induction

Transformers

You might have come across the word “transformer”. It is a device which is used for stepping up or stepping down the AC voltage. To transport electricity by means of transmission lines to distant places the voltage of the electric current has to be increased in other words the voltage should be stepped up. Huge transformers are installed along the transmission lines at certain distances. You might have seen them. At the receiving centre and at the distribution point for domestic supply the voltage has to be decreased or stepped down.

A transformer works on the principle of electromagnetic induction in general and mutual induction in particular. Production of induced emf in one coil (secondary) due to change of current in a neighbouring coil (primary) is called **mutual induction**.

Transformer which increases the input voltage of an AC source is known as a step up transformer. The transformer which decreases the input voltage of an AC source is known as a step down transformer. Rectangular laminated soft iron core sheets which are placed on one above the other are used to construct the transformers. Following figures indicate the construction of step down and step up transformers.

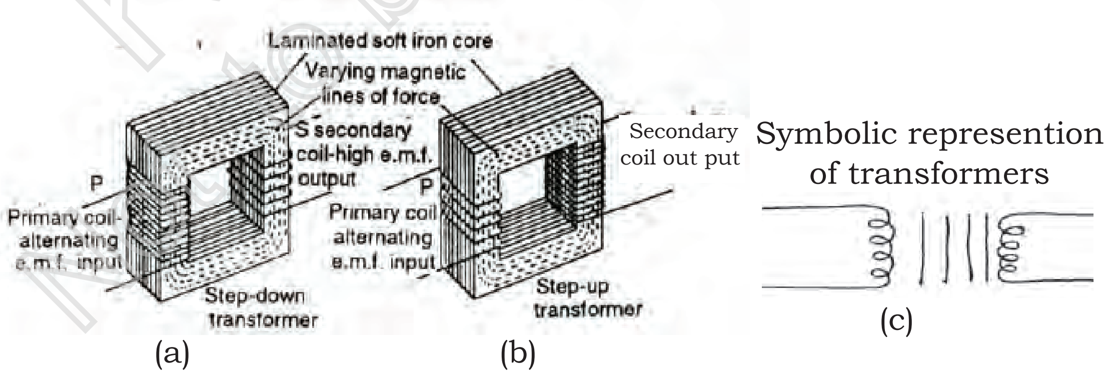

Laminated soft iron core
Varying magnetic lines of force
S secondary coil-high e.m.f. output
P
Primary coil-alternating e.m.f. input
Step-down transformer
P
Primary coil alternating e.m.f. input
Secondary coil out put
Step-up transformer
Symbolic represention of transformers
(a)
(b)
(c)

Fig. 16.12 Transformers

Insulated copper wire is wound around either side of the soft iron core. The winding on one side which is connected to input source is called **primary coil**. The winding on the other side from which output voltage is obtained is called **secondary coil**.

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The magnitude of the emf induced in the secondary coil of a transformer depends on the following.

i) emf in the primary ii) Number of turns in the primary

iii) Number of turns in the secondary iv) The core material

$$\frac{\text{emf in the secondary}}{\text{emf in the primary}} = \frac{\text{Number of turns in the secondary}}{\text{Number of turns in the primary}}$$

$$\boxed{\frac{Vs}{Vp} = \frac{Ns}{Np}}$$

$\frac{Ns}{Np}$ is called the turns ratio of the transformer.

The relation ship between current and voltage of primary and secondary coils of a transformer can be expressed as,

$IpVp = Is\ Vs$ or $\frac{Vs}{Vp} = \frac{Ip}{Is}$

Current X voltage of primary coil = current x voltage of secondary coil.

The relationship suggests that the primary of a step up transformer should have less number of turns than the secondary and should be thick to sustain larger electric current. The primary of a step down transformer should have more number of turns than the secondary. You will study more about transformers in higher classes.

Example

If an AC source of 250 volts has to be stepped down to 10 volts, what should be the turns ratio of the primary coil and secondary coil?

Solution :

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$

$$\frac{10}{250} = \frac{Ns}{Np} \text{ or } \frac{Ns}{Np} = \frac{1}{25}$$

Therefore No of turns of the primary :

No of turns of secondary = 25:1

Induction coil

You know that for discharge tube experiment high voltage is required. How to produce high voltage from a low voltage DC source? An induction

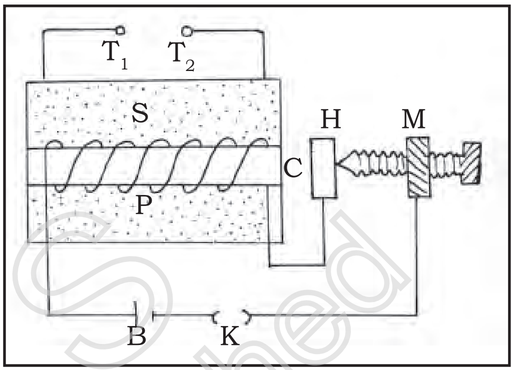


Fig. 16.13 Induction coil

coil is a device for obtaining a very high DC voltage starting from a low DC voltage. An induction coil consists of few turns of a primary coil 'P'. of thick insulated copperwire wound over a soft iron core connected to a battery. 'S' is a secondary coil of large number of turns wound over the primary coil. 'M' is a make and break arrangement. When the DC current flows in the primary, 'C' gets magnetised. The iron head 'H' of the switch 'M' is attracted towards 'C' so, The circuit breaks and the current in primary stops. 'C' gets demagnetised and 'H' comes back. The process repeats. During make and break of the circuit, large emf is induced in the secondary. The voltage depends on the turns ratio. Since the number of turns in secondary is very large, a large voltage in produced in the secondary.

Extended activity

From motor winding shop get one metre 22 guage insulated copper wire. You can use the wire of a discarded transformer also. Keep the compass inside the card board box and glue it to the box. Wind the wire over the box such that turns pass above the compass meddle. Scrap the enamel at the loose ends of the wire. Your galvanometer is ready. Test it using a weak torch cell.

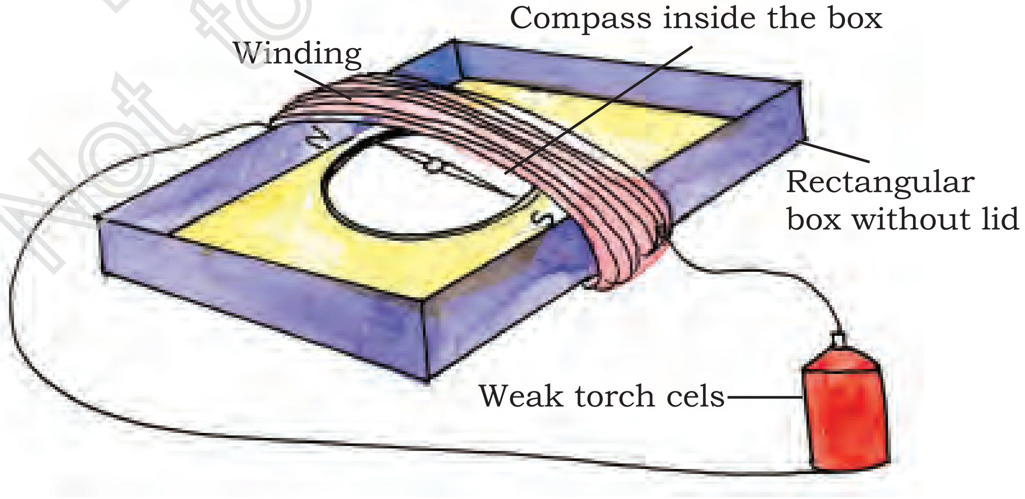


Fig. 16.14 Galvano meter

While using it remember that the coil should be in the north and south direction. That means the needle and the coil should be parallel to each other.

Exercise

I. Fill in the blanks

1. Device that converts mechanical energy into electrical energy is ________________ .
2. The type of electric current that changes its direction twice during one cycle of the dynamo is called ______________ .
3. Device that converts electrical energy into mechanical energy is _________________ .
4. In Fleming's rule the middle finger indicates the direction of __________________ .
5. The device that detects the induced emf is called _____________.

II. Four alternatives are given to each of the following incompleted statement / question. Choose the right answer

1. Electricity and magnetism are mutually

    a. complementary
    b. opposite
    c. equal and opposite
    d. strongest forces

2. The SI unit of potential difference is

    a. ohm
    b. volt
    c. coulomb
    d. ampere

3. Carbon brushes are not necessary in a dynamo, if the coil remains stationary and the magnet moves, because

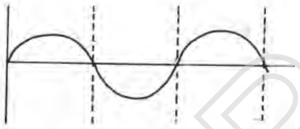
    a. current is drawn from a stationary source
    b. current is drawn from a moving source
    c. direct current is produced
    d. it is not necessary to reverse the direction of the current.

4. AC is not suitable for electrolysis because

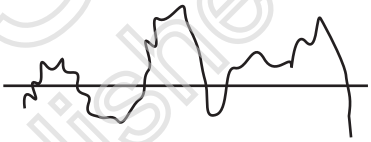
   a. it has large current
   b. it has high voltage
   c. polarity of the current changes
   d. polarity of the current remains the same

5. Which of the following graph indicates direct current?

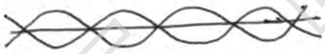
   a.



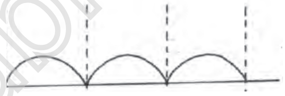
   b.



   c.



   d.



6. When the plane of the rectangular coil is parallel to the direction of the magnetic field in a dynamo, then

   a. induced current will be zero
   b. induced current is maximum
   c. AC is produced
   d. DC is produced

7. A small AC dynamo is connected to a galvanometer and gently rotated, then the needle of the galvanometer,

   a. moves toward left
   b. moves to wards right
   c. remains in the same position
   d. moves towards both right and left

8. A dynamo makes 100 cycles per second. The frequency of the AC is

   a. 100 Hz b. 200 Hz c. 50 Hz d. 400 Hz

III. Answer the following

1. What is electromagnetic induction?
2. State Faraday's laws of electromagnetic induction.
3. State Fleming's right hand rule. For what purpose is it used?
4. Draw a neat diagram of the following and label the parts i) AC dynamo ii) DC dynamo iii) DC motor.
5. Mention any two uses of DC and two uses of AC.

IV. Give reasons for the following

1. In the experiment conducted by Faraday the induced electric current was not DC.
2. Split rings are used instead of slip rings to construct DC dynamo.
3. Stationary coil and stationary magnet can not produce induced electric current.

V. Draw neat diagrams of the following and label the parts

i) step down transformer

ii) step up transformer

iii) induction coil

* * *

CHAPTER 17

ELECTRONICS

After studying this chapter you :

- know the difference between conductors, Insulators and semiconductors.
- know how the conductivity varies with temperature in conductors and semiconductors.
- differentiate between types of semiconductors n-type, p-type.
- explain junction diode, forward biasing and reverse biasing.
- mention uses of diodes.
- distinguish between types of transistors npn and pnp.
- mention uses of transistors.

The term electronics is originated from the word Electron. It was first applied to the study of electron movement and its behavior.

Now electronics is an extended field of Physics and Engineering both pure and applied. Many electronic devices are constructed which cover wide range of Industrial and Military requirements. Recent advances in electronics are adopted in the field of communications and medical science in particular and science in general. The most recent advances in electronics include digital circuits, micro processor, digital computers, photo electrons, laser technology, nano technology and so on.

You know about good and bad conductors of heat. You know good and bad conductors of electricity also. Usually good conductors of heat are good conductors of electricity also. This is because, mobile electrons are usually responsible for the conduction of heat and electricity. But there are exceptions like diamond and mica. Diamond conducts heat by lattice vibrations and not by electrons. They are conductors of heat but cannot conduct electricity.

Both conductors and insulators are part of electrical gadgets. Ex : tester - the metallic rod is conductor and grip material is an insulation.

Activity 17.1

Observe the different parts and working of a tester in your laboratory

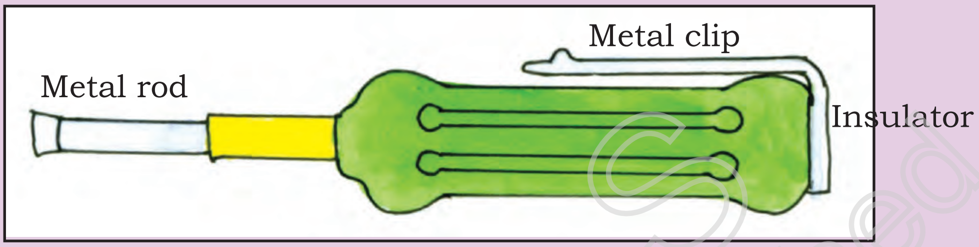


Fig 17.1 Tester

What are semi conductors?

You know that the electrical conductivity of a good conductor and like copper or silver is very high and insulators like glass plastics have very low conductivity. Some substances like silicon and germanium have conductivity lying in between that of conductors and insulators. Such substances are called semiconductors. Silicon and Germanium are two typical semiconductors. Why are these intermediates important? This is because of their unique properties.

Differences between conductors and semi conductors are given below.

Conductors	Semi Conductors
Conduction is very high.	Conduction is very poor.
Resistance is low.	Resistance is higher than in conductor.
On heating resistance increases.	On heating resistance decreases.

The property of a semiconductor can be understood by the molecular structure of these materials. The atoms of the semiconductors are held together in terms of covalent bond. (Recall covalent bond).

Silicon has 4 valence electrons. Each atom forms 4 covalent bonds with its four near by neighbours.

At room temperatures some electrons become free due to thermal energy available from the surroundings.

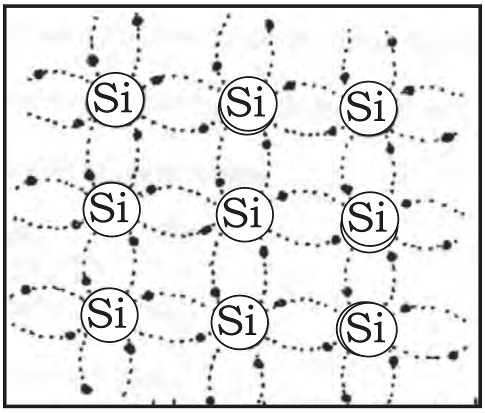


Fig 17.2 structure of silicon crystal

These free electrons conduct slightly. Thus semi-conductors are conducting, and conduction increases as temperature increases.

Do You Know this ?

1) 14th group elements are semi conductors except carbon. Because the valence electrons have such a low energy that they can not become free by absorbing normal energy from the surroundings.

2) Silicon is more widely used than Germanium. Why?

Conductivity in Semiconductors

Atoms of Silicon and Germanium have four electrons in their outer most shell. These electrons form covalent bond with the neighbouring atoms and are not free at low temperature. Hence they behave like insulators.

However when a small amount of thermal energy is available from the surroundings a few covalent bonds are broken and few electrons are set free to move. Even at room temperature, good number of electrons are dissociated from their atoms and this number increases with rise in temperature. This leads to enhanced conductivity gradually.

Know this

At very low temperatures (near 0°k) the semi conductor behaves like an insulator.

When an electron is detached from the co-valent bond, it leaves a vacancy which behaves like a positive charge. An electron from a neighbouring atom can move on to this vacancy leaving a neighbour with a vacancy. Such a vacancy is called a **hole**. Hole acts as a positive charge.

Can you?

Imagine a conference hall, where there is only one seat vacant. Can you guess how this vacancy can be made to move?

Types of Semiconductors

In a semiconductor there are two kinds of current carriers - Electrons and Holes. The total current in the semiconductor is the sum of electric current due to the flow electrons (called electron current I_e) and due to the apparent flow of holes (called hole current I_h). $I = I_e + I_h$

In a pure semiconductor electrons and holes are always present in equal numbers and it is called or **Intrinsic semi conductor**.

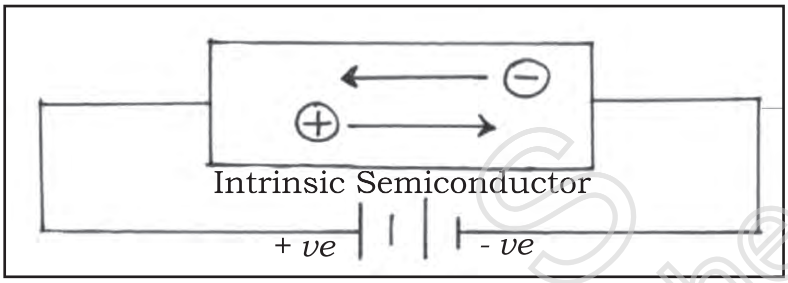


Fig. 17.3 Motion of charges in semi conductors

Extrinsic Semiconductors

Conductivity of semiconductors can be changed by adding small amount of impurities (other elements) to it. These impurities are called Dopant. Such semiconductors are impure or extrinsic semiconductors.

When a few atoms of trivalent or Pentavalent element is added into pure crystal of Ge or Si an extrinsic semiconductor is produced. The process of adding impurity atoms is called **Doping**.

Types of Extrinsic Semiconductors

Depending upon the type of impurity atom doped in the intrinsic Semiconductors there are two types of Extrinsic Semiconductors. They are classified

1) n-type Semiconductors and 2) p-type Semiconductors.

They are used in preparing diodes and transistors

Differences between intrinsic and extrinsic Semiconductors

	Instrinsic Semiconductors		**Extrinsic Semiconductors**
1	Intrinsic semiconductors are the crystals of pure elements like germanium and silicon.	1	When some impurity atoms are added in the intrinsic semiconductor an extrinsic semiconductor is obtained.
2	The number of electrons is equal to number of holes. $n_e = n_h$	2	The number of electrons is not equal to the number of holes. $n_e \neq n_h$

1) n - type semiconductors

When pentavalent impurity atoms are added to pure germanium or silicon crystal, we get an extrinsic semiconductor known as n-type semiconductor.

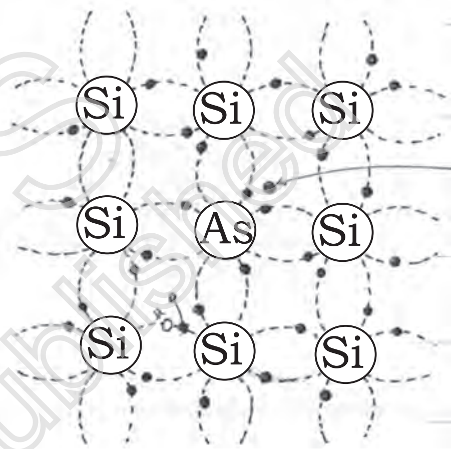


Fig. 17.4 Formation of n-type semiconductor

Pentavalent impurity, say arsenic (antimony or phosphorous) has five valence electrons. When arsenic atom is added to the silicon crystal it forms four co-valent bonds by sharing its four electrons with the neighbouring silicon atom. The fifth valence electron of arsenic atom is set free. In addition the usual electron hole pair formation due to thermal energy also takes place in semi conductor. So the number of electrons will be more than number of holes in n type semi conductor. The added pentavalent impurity donates electrons to the crystal and it becomes n - type semi conductor. In n-type semi conductors majority charge carriers are electrons and minority charge carriers are holes, which are thermally generated.

2) p - type semi conductors

When a trivalent impurity is added to pure germanium or silicon crystal, we get extrinsic semiconductor known as p-type semi conductor.

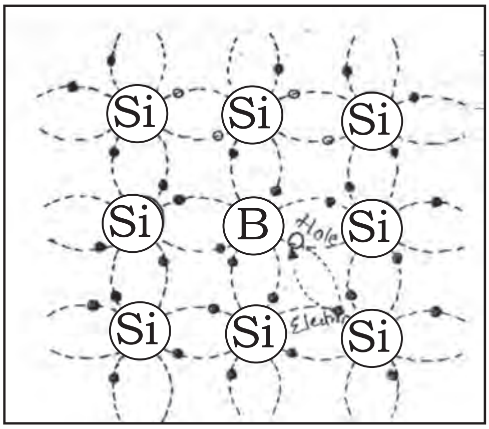


Fig. 17.5 Formation of p-type semi conductor

Trivalent impurity atom say indium (or boron, or gallium or aluminum) has three valence electrons. When it is added to silicon crystal it forms three covalent bonds with the neighbouring silicon atoms. The fourth bond remains incomplete which has a deficiency of one electron. This deficiency of electron acts as a hole. This hole accommodates the electrons from the neighboring covalent bond to fill itself. Then a new hole is created and thus there will be apparent motion of holes. These holes act as current carriers. In addition to the usual electron hole pair formation due to the thermal energy. The extra hole created by the impurity atom the total number of holes will be more than the total number of electrons in the crystal. Hence, holes act as majority charge carriers and electrons act as minority charge carries.

	n-type semiconductor		**p-type semiconductor**
1	When pentavalent impurity atoms like As, Sb etc., are added to the intrinsic semi conductor, we get n- type semi conductor.	1	When trivalent impurity atoms like gallium and indium etc are added in the Intrinsic semi conductor, we get p-type semi conductor
2	The majority carriers in n-type semi conductor are electrons and minority carriers holes due to thermal energy.	2	The majority carriers in p-type semi conductor are electrons facilitated by holes, minority carriers are electrons.

Diodes : A single crystal of semi conducting material whose one side is doped with donor impurity and the other side is doped with acceptor impurity forms a p -n junction diode or as a semi conductor diode.

Note

There will be diffusion of electrons and holes across the boundry of p and n regions during the formation of a p-n junction. Very soon an equilibrium state is reached. In equilibrium, a potential barrier is established. This potential is called junction potential. This stops further flow of charge carries, unless an external voltage is applied. The junction potential for silicon is 0.7 v and for Germanium 0.3v. The thin region around the junction containing immobile positive and negative charges is called depletion region.

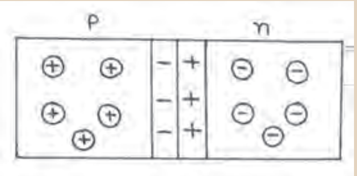


Fig. 17.6

Forward and Reverse biasing

When an external battery of e. m. f. is connected to p - n junction it is said to be biased and the applied voltage is called bias voltage.

When the positive terminal of the battery is connected to p-region and the negative terminal of the battery is connected to n - region of the junction diode it is said to be forward biased (fig 17.7).

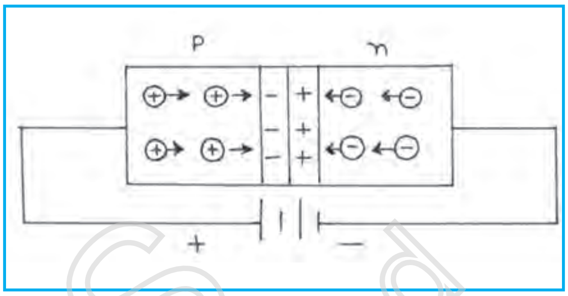


Fig. 17.7 Forward biasing of Diode

The external voltage overcomes the junction potential and provides an easy path for the flow of charges across the junction. The flow of electrons from n to p and holes from p to n constitutes a forward current from p to n[about MA]. Thus the diode offers a low resistance.

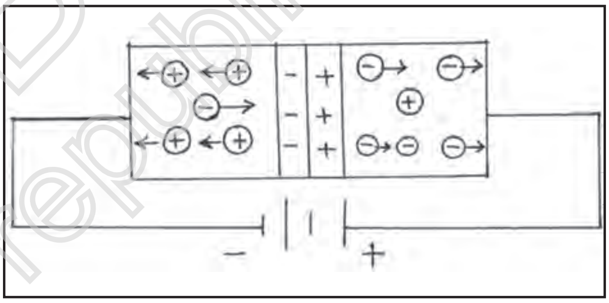


Fig. 17.8 Reverse biasing of diode

When the positive terminal of the battery is connected to the n region and negative terminal is connected to p - region of the p-n junction it is said to be reverse biased. (fig)17.8

In this case the charge carriers are repelled from the junction and no current flows through the junction. Thus the diode offers a high resistance.

Note

There is a small flow of current during reverse bias, this is due to minority charge carries electrons in p region & holes in n region.

The working of a p-n junction diode which works unidirectionally can be best compared with valves in your heart.

Activity 17.2

Try this

D - Diode, A - Anode, C - Cathode, B - Battery, K - Plugkey, L - Lamp

When +ve Terminal of a battery is connected to A and

-ve Terminal is connected to C the lamp glows.

When +ve Terminal of a battery is connected to C and

-ve Terminal is connected to A the lamp does not glow. Why?

This shows unidirectional action of diode.

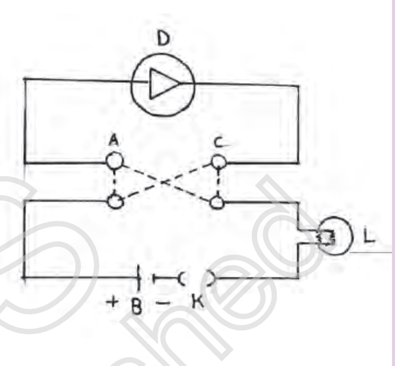


Fig. 17.9 Electrical Circuit of a diode

Thus p-n junction diode allows current to pass through, preferentially in one direction.

This action is useful in rectifying AC voltage into DC voltage and the device is called **'rectifier'**.

Fig. 17.10 shows the circuit symbol of a diode. The p side is called anode and the n side is called cathode. The arrow mark indicates the conventional direction of flow of current from p side to n side.

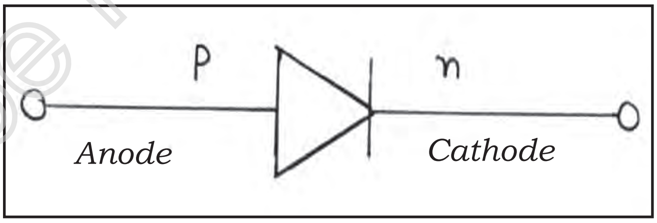


Fig. 17.10 Electronic circuit symbol of diode

Since diode allows current to pass only when it is forward biased when AC voltage is applied across a diode, the current flows only in that part of the cycle when diode is forward biased. This property is used to rectify AC voltages. And the device used for this purpose is called rectifier.

Applications

In view of rectifying action and current detecting action diode has a number of applications :

1. Diodes are used to convert A. C. in to D. C.
2. They are used in voltage regulation systems.
3. They are used in Logic circuits which are used in computers.

Types of Diodes

1) Light emitting diode LED. They are used in lighting, display units of electric and electronic devices.

2) Zener diode - Used in voltage stabilisers.

3) Photo diode - Light sensitive semiconductor.

4) Laser diode (LD) - Works on the principle of laser. They are used in optical fibre communications.

Transistors

The term transistor is simplified form of two words. Transfer and resistor. Transistor is a resistor that amplifies electrical signal passing through its input to output terminals. It is a three terminal semiconductor device. It consists of either one p-type region sandwiched between two n-type regions (n p n transistor) or one n - type region sandwiched between two p - type regions (p n p transistor). The middle region is called base and the two end regions are called the emitter and the collector.

Transistors

Transistor was first fabricated in 1947 at the Bell Telephone laboratories, by three American physicists John Bardeen, Walter H. Brattain, and William B. Shokly, they were later awarded noble prize in physics in 1956.

After the invention of junction transistor now known as Bipolar Junction Transistor (BJT) several new types of transistors were developed.

A transistor has three doped regions forming two p - n junctions between them. There are two types of transistors as shown in fig. 17.12 & 17.13.

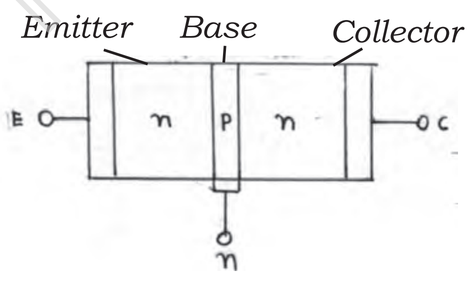


Fig 17.12 npn transistor

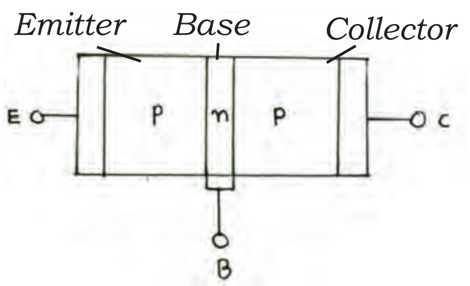


Fig 17.13 pnp transistor

1. **n - p - n transistor** - Here two segments of n - type semi conductor are separated by a segment of p - type fig 17.12
2. **p- n- p transistor** - Here two segments of p - type semi conductor (termed as emitter and collector) are separated by a segment of n - type semi conductor (termed as base) fig. 17.13

The schematic representation of n - p - n and p - n - p configurations are shown in fig 17.14 and 17.15

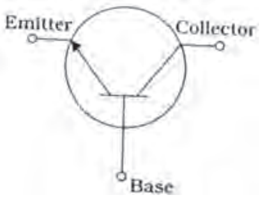


Fig 17.14 npn transistor

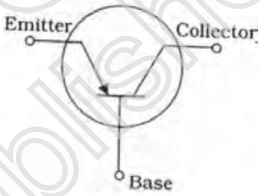


Fig 17.15 pnp transistor

All these three segments of a transistor have different thicknesses and their doping levels are also different.

In the schematic diagram shown for n - p - n and p - n - p transistor (fig) 17.14 and (fig) 17.15 the arrow head shows the direction of conventional current in the transistor.

Explanation of three segments of a transistor

1. **Emitter :** This segment is on one side of a transistor. It is of moderate size and heavily doped. It supplies a large number of majority carriers for the flow of current through the transistor.
2. **Base :** This is the central segment. It is very thin and lightly doped. It regulates the flow of charges from emitter to collector.
3. **Collector :** This segment collects a major portion of majority carriers supplied by the emitter. The collector side is moderately doped and is larger in size compared to emitter.

Activity 17.3 Types of Transistors

Visit an electronic shop and be familiar with different types of transistors.

Bipolar junction transistor (BJT). Field effect transistor (FET), metal oxide semiconductor field effect transistor (MOSFET), junction effect transistor(JET), metal semiconductor field effect transistor.

Transistor Biasing

For normal operation of the transistor :

1. Emitter base junction is forward biased.
2. Collector base junction is reverse biased.

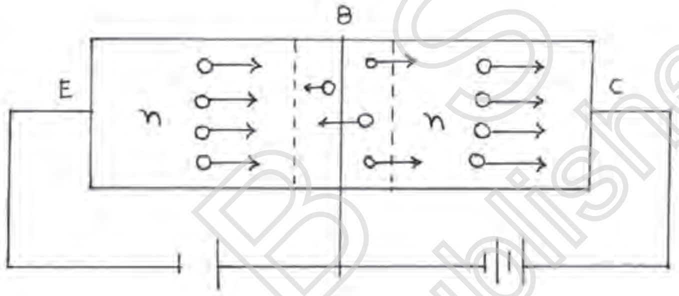


Fig 17.16 simple transistor circuit

Action of a Transistor

Fig 17.16 shows circuit diagram of biasing an n p n transistor. The emitter n region is given a small negative voltage with respect to the base p region to allow the forward flow of current across the n - p junction. The collector n region is given a large positive voltage with respect to base p region to prevent the reverse flow of current. Electrons from the emitter are attracted towards the collector and a current flows through an external circuit.

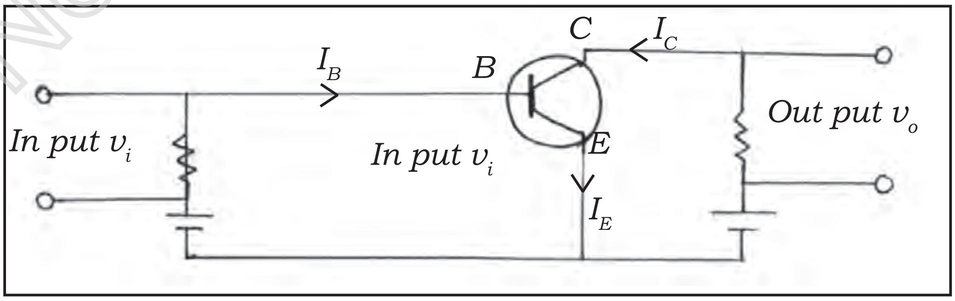


Fig. 17.17 circuit diagram of a npn Transistor amplifier

Fig 17.17 shows the circuit of a common emitter amplifier. In this circuit a weak signal is applied across a resistor in the emitter base circuit (called input signal). The output signal is taken across another resistor (called load) in the collector emitter circuit. Small changes in the input signal (voltage) result in large changes in output signal (voltage) Thus transistor acts as an amplifier.

Activity 17.4

Draw a suitable circuit diagram of p-n-p transistor and name its parts.

Note

E/B junction is always forward biased C/B junction always reverse biased.

$$I_E = I_B + I_C$$

Since a transistor is a 3 terminal (and not a 4 terminal) device one of its terminal has to be common to the input and output circuits.

Applications of Transistor

Transistor is used in

1. Amplifiers 2. Oscillators 3. Switching circuits

Oscillator is a device to produce electric oscillations of a desired frequency.

Know this

There are two types of rectifiers

1. Half wave rectifier

2. Full wave rectifier

Reference Book : Text Book of physics, II year PUC

Superconductivity

The property by virtue of which certain materials show almost zero resistance at a very low temperature is called superconductivity. This phenomenon was first discovered by H. Kamerlingh Onnes in 1911. In the case of mercury, resistance of mercury (Hg) drops abruptly to zero at 4.2 k. The materials which show property of superconductivity are called super conductors.

Critical Temperature

The temperature below which a material becomes a superconductor is called critical temperature (T_c).

Bell laboratory has developed super conductor at a temp of 40 k. by using oxide of a compound of lanthanum, barium and copper. Once the current is set up in a super conductor, it continues to flow for a very long time without decrease in strength.

Uses of Super conductors

1. They are used in powerful electromagnets.
2. High temperature super conductors are used in microwave devices.
3. Super conductor magnets are used in magnetic resonance imaging (MRI)

The most important feature of the super conductor is that once current is set up in a super conductor ring, it will continue indefinitely even if the battery connected to it is switched off.

At present the upper limit of temperature at which a material behaves as super conductor is about 125 K.

A further rise in the critical temperature may revolutionalise the electrical and electronics technology.

A group of scientists from Indian Institute of Science Bangalore under the leadership of professor C.N.R. Rao have done a remarkable work in the field of super conductivity. Recently government of India has honoured him by awarding **Bharath Ratna**.

Exercise

I. Four alternatives are given to each of the following incomplete statement / question. Choose the right answer

1. The conductivity of a semi conductor is

   a. greater than the conductivity of metals
   b. less than the conductivity of metals
   c. equal to the conductivity of metals
   d. intermediate between the conductivity of metals and insulators

2. The conductivity of a semi conductor can be increased by

   a. heating the semi conductor

   b. doping the semi conductor

   c. both (a) and (b)

   d. none

3. In a n - type semi conductors which of the following statement is true

   a. electrons are majority carrier and trivalent impurity are the dopants.
   b. electrons are minority carrier and pentavalent atoms are dopants.
   c. holes are minority carrier and pentavalent atoms are dopants.
   d. holes are majority carrier and trivalent atoms are the dopants.

4. Which of the statements given in question (3) is true for p type semi conductor ?

5. When a forward bias is applied to p-n junction it

   a. raises the potential barrier.

   b. reduces the majority carrier current to zero.

   c. lowers the potential barrier.

   d. none of the above.

6. For transistor action which of the following statements is correct?
   - a. base, emitter and collector regions should have similar size and doping concentration.
   - b. the base region must be very thin and lightly doped.
   - c. the emitter junction is forward biased and collector junction is reverse biased.
   - d. both emitter junction and collection junction are forward biased.

II. Fill in the blanks

1. In p-n-p transistor the majority carriers are ___________.
2. In n-p-n transistor the majority carriers are ___________.
3. During reverse bias of the diode there is a small current of the order of micro ampere due to ___________.
4. In an npn transistor p type semi conduct is sandwiched between ___________.
5. Pentavalent impurity is called ___________ impurity.
6. Triavalent impurity is called ___________ impurity.
7. The traces of impurity added for doping are called ___________.

III. Answer the following

1. What is electronics?
2. What are conductors and insulators? Give examples.
3. Mention any four electronic gadgets.
4. Which are the areas influenced by electronics?
5. What are most recent advancements in the field of electronics?
6. What are semi conductors? Give examples.

7. How many electrons are there is the outermost shell of silicon atom?
8. What is called a hole?
9. Distinguish between extrinsic and intrinsic semi conductors.
10. Explain the term ‘doping’
11. Distinguish between n type and p type semi conductors.
12. Name two pentavalent impurities.
13. Name two trivalent impurities.
14. What is a semi conductor diode or junction diode?
15. What is meant by forward bias and reverse bias of a diode? Indicate in a figure.
16. Give the circuit symbol of a diode.
17. Mention important characteristics and applications of a diode.
18. What is a transistor? Distinguish between p-n-p and n-p-n transistor.
19. What are the functions of three regions of a transistor?
20. Mention the applications of a transistor.

* * *

CHAPTER 18

BEHAVIOUR OF GASES

After studying this chapter you

- learn the important properties of gases.
- understand Charles Law which explains behaviour of gases at constant pressure.
- make a list of the application of Charles Law.
- understand Boyles Law which explains behaviour of gases at constant temperature.
- make a list of the application of Boyles Law.
- understand diffusion in Gases.

Already you are familiar with the properties of solids, liquids and gases. You know that solids have definite shape and volume. Liquids have fixed volume but take the shape of container. But gases neither have a definite shape nor definite volume ! How strange they are !

Gas is the simplest and most interesting state of matter. Throughout our life we remain immersed in the ocean of air. Let us study how gases behave under certain conditions.

Know this

The word 'gas' is derived from 'chaos' which means 'confused state'. Gas is the most confused state of matter. Since gases move in all possible directions with all possible velocity.

Main features of gases are

1) Gases are highly compressible.

2) Gases exert pressure equally in all directions.

3) Gases mix evenly in all proportions without any mechanical aid.

4) Gases are least dense than other two states of matter.

The gas laws which you are studying now are the fruit of research carried on physical properties of gases for several centuries.

Activity 18.1 The Magic Balloon!

Take hot water in a bottle. Take a balloon. Inflate it with little air and tie it over the mouth of hot water bottle. What do you observe? What is your inference? The balloon increases in size. It is because temperature increases kinetic energy of gas molecules of balloon. This increases the random movement of gas molecules. Hence volume increases gradually.

Relationship between volume and temperature of gases - Pressure is kept constant (Charles Law)

Fig.18.1 Charles

Charles (in 1787) and Gay Lussac (in 1806) performed several experiments on gases independently to improve hot air balloon technology. Charles found experimentally that for a fixed mass of gas at constant pressure, the volume expands or contracts as the temperature varies.

Charles and Gay Lussac both found that under constant pressure degree rise in temperature, the volume of a gas increased by $\frac{1}{273}$ of the original volume at 0°C (273K)

Know this

The temperature -273°C is called absolute zero or zero kelvin (0 K). Kelvin is the SI unit of temperature. A temperature scale with absolute zero, as its starting point is called absolute or kelvin scale of temperature. At 0 K all gases occupy minimum volume !

Charles Law

Charles Law states that "at constant pressure, the volume of a fixed mass of a gas is directly proportional to its absolute temperature".

Mathematically it is expressed as -

$V \alpha T$ (at constant pressure)

or $V = KT$ (where 'K' is proportionality constant)

In the above magic balloon activity you drawn same inference !

Let us consider a given mass of gas ‘G’. At temperature T_1 (in Kelvin) and volume V_1 (in liters). At same pressure, temperature of gas is raised to T_2 then volume increases to V_2(in liters).

According to Charle’s Law,

$$V_1 = KT_1$$

$$\therefore \frac{V_1}{T_1} = K \ldots\ldots\ldots\ldots (1)$$

Similarly $V_2 = KT_2$

$$\therefore \frac{V_2}{T_2} = K \ldots\ldots\ldots\ldots (2)$$

From the equation (1) and (2) we can write Charles Law equation as

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = K \text{ (at constart pressure)} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Application of Charles law

- Several times you might have played with balloons. You may have observed that balloons pops out during hot summer more frequently than in winter. Why ?
- Hot air balloon technology used earlier also had the application of charles law.
- Automobile tyre pressure maintenance has the application of charles law.

Make a list of such experiences and discuss with your teacher.

Activity 18.2

Take a vessel with water. Heat it. Observe the formation of bubbles and their size. Why do these bubbles increase in the size as they raise?

Upper layers of water exert a lot of pressure on air bubbles. Hence, they are smaller in size. But the pressure decreases as bubbles rise to the top. Hence, they grow bigger!

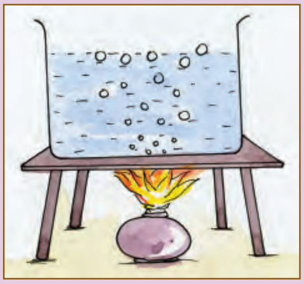


Fig. 18.2

Relationship between Volume and Pressure of Gases, when temperature is kept constant (Boyle's law)

Fig. 18.3
Robert Boyle

Robert Boyle was the pioneer scientist who tried to measure properties of gases. In the early of 17th century Boyle formulated famous Boyle's Law.

Boyle's law states that **at constant temperature, the volume of a given mass of dry gas is inversely proportional to its pressure**.

If 'V' is the volume of certain mass of gas, under pressure 'P' at constant temperature. According to Boyle's Law,

$V \alpha \frac{1}{P}$ (at constant Temperature) ....(4)

$V = K \times \frac{1}{P}$ (K is proportionally constant)

$PV = K$.......(5)

Interesting fact!

To prove Boyle's Law Royal Society designed a ***U*** *shaped gigantic glass tube. Carrying of this glass tube attracted common mass and it turned into a huge procession !*

Think it over

1] When you exert pressure on air pillow, its size gets reduced. Give reasons ?

2] When you blow air into a balloon, not only there will be increases in its pressure but also its volume ! Is it a violation of Boyle Law ?

Let us examine validity of Boyle's Law with experimental data.

Trial	Pressure(P) in Pascal's	Volume (V) in Liters	Pressure X Volume (PV)
1	1×10^5	1	$1 \times 10^5 \times 1 = 1 \times 10^5$
2	2×10^5	0.5	$2 \times 10^5 \times 0.5 = 1 \times 10^5$

3	4×10^5	0.25	$4\times10^5\times0.25 = 1\times10^5$

From this data we can conclude that "product of the volume and pressure of a given mass of dry gas is a constant".

P × V = Constant

Let a particular mass of gas occupies volume V_1 litres at pressure P_1 volume V_2 litres at pressure P_2 .

According to Boyle's Law,

$P_1V_1 = P_2V_2$ = Constant [at fixed temperature(T)].......(6)

Problem 18.1

$2l$ of gas enclosed in a vessel at 2×10^5 Pa pressure and allowed to expand about $4l$ under constant temperature. What would be final pressure ?

Solution :

$V_1 = 2l$; $V_2 = 4l$

$P_1 = 2 \times 10^5$ Pa ; $P_2 = ?$

According to Boyle's Law $P_1V_1 = P_2V_2$

$$\therefore P_2 = \frac{P_1V_1}{V_2}$$

$$P_2 = \frac{2 \times 10^5 \times 2}{4} = 1 \times 10^5 \text{ Pa}$$

Activity 18.3

A student conducts an experiment to understand the relation between pressure and volume of a gas. Unknowingly he forgot to record some of the observations. Calculate the missing values and state the law used.

Trial No	**1**	**2**	**3**
Pressure (P) in Pascals	1.5×10^5 Pa	2.5×10^5 Pa	-
Volume (V) in Liters	-	6	5
P × V	15×10^5	-	15×10^5

Applications of Boyle's Law in our daily life

1) Deep sea fishes die when they brought suddenly to surface due to low pressure. Similarly a Scuba diver's life is under threat when he suddenly come to surface quickly !

2) Popping of balloon when squeezed is due to increase in the pressure.

3) Boyle's Laws application, can be verified in daily life situations like breathing in animals, filling up cheeks with air, filling air to vehicles tyres.

4) We often feel a very uneasy pain in ears while in a plane during ascending or descending due to imbalance in pressure inside and outside of eardrum. Then you have to open your mouth to allow the excess of pressure to escape!

Combined gas law

Let us consider equations

$$\frac{V}{T} = \text{constant (Charles law)}$$

P x V = constant (Boyle's law)

On combining above laws, we can write

$$\frac{PV}{T} = \text{constant} \;..........(7)$$

Note : For 'n' moles of a dry gas, combined gas law equation is written as PV = nRT. Where 'R' is gas constant.

Diffusion

Our nose can identify the aroma of food from few meters itself when it is still hot but not the smell of cold ice cream. Why ?

You know that burning kerosene does not produce much smell but when it is ceased, produces strong smell. How will you explain these? This is due to diffusion process.

Whenever two or more non reactive gases are brought in contact they form homogeneous mixture. **Random movement gaseous molecules from the region of higher concentration to the region of lower concentration is known as diffusion.** It is a physical process.

Smell of hot food reaches faster because of faster rate of diffusion. While smell particles of cold food diffuses slowly. So you have to reach the food to detect the aroma.

Surprising fact!

Our nose is a powerful sense organ. Nose needs only a few thousand molecules to detect smell. Where as eye needs at the order of 10^{20} molecules.

When kerosene is burnt, only few molecules of kerosene vapour diffuses into air. On ceasing the fire the unburnt hot vapours of kerosene enters into air and strong smell is felt.

Let us conduct an activity to understand the diffusion process.

Activity 18.3

Take a glass tube. Keep a cotton plug dipped in the Conc. HCl to one end of the glass tube and cotton plug dipped in liquid ammonia in another end of glass tube. Observe the change for few seconds.

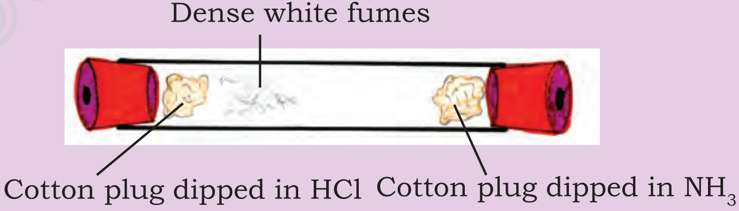


Fig 18.4 Deffusion

You will observe dense white fumes near the HCl end. What is your inference?

Due to diffusion of HCl vapours and ammonia vapours. Dense white fumes of ammonium chloride (NH_4Cl) is produced.

Think

Why is dense white fumes is seen near HCl end ?

Diffusion takes place only when the gases do not react with one another. Gases diffuse through microscopic pores of a pot. Hence it is used to compare the rates of diffusion of different gases.

The rate of diffusion of a gas is equal to the volume of a gas diffusing per unit time.

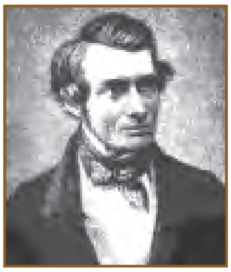


Fig. 18.5 Graham

Graham in 1829 postulated a law, commonly known as **Graham's Law of Diffusion**.

It states that **"the rate of diffusion of a gas is inversely proportional to the square root of its density at the given temperature and pressure."**

Mathematically, it can be written as -

$r \alpha \frac{1}{\sqrt{d}}$ (at constant Temperature) Where, r = rate of diffusion

$r = K \frac{1}{\sqrt{d}}$ ....(8) d = density of gas

or $K = r\sqrt{d}$ k = proportionality constant

Relationship between diffusion and mass

Consider the equation,

$r = \frac{K}{\sqrt{d}}$ we can rewrite it

as, $r = \frac{K}{\sqrt{\frac{m}{v}}}$ because $d = \frac{\text{mass(m)}}{\text{volume (v)}}$

$\therefore r = K\sqrt{\frac{v}{m}}$ or $r \alpha \frac{1}{\sqrt{m}}$..........(9)

This clearly indicates the rate of diffusion is inversly proportional to square root of mass of the gas.

Graham's law answers formation of dense fumes at HCl end in the above mentioned activity 18.4

As HCl vapour is denser than ammonia gas it diffuses slowly, while lighter ammonia vapours move with more velocity and both the gases reacts and produce dense white fumes of ammonium chloride near Hydrocloric cotton plug end.

Activity 18.5

Let us continue the earlier activity 18.4 Heat the glass tube at HCl end with a spirit lamp. Tabulate your observation. What happens if you heat at both ends? Record your observations. What is your inference ?

Know this

Bhopal gas tragedy is due to poisonous gas methyl isocyanate. The poisonous gas produced by the chemical combination of phosgene gas and methyl cyanide. This killed several hundred lives including domestic animals and human beings. But cockroaches, ants, mosquitoes and such small creatures survived ! What may be the reason for this ?

That is due to uneven diffusion ! Methyl isocyanate (MIC) is denser than air. Hence it was unable to diffuse in the crevices. Hence these animals survived !

Think

When leakage of LPG is detected, it is advised to open all the doors and windows and not to operate any electrical switches. Why ?

Exercise

I. Answer the following

1. Define Charles Law.
2. Define Boyles Law.
3. What do you mean by Diffusion ?
4. Define rate of diffusion.
5. What is the relation between diffusion and mass of the gas ?
6. In an experiment for a fixed volume of a dry gas, pressure recorded is 2500 Pa. When the pressure was decreased by 500 Pa, the gas occupied a volume of 2400 litres. Calculate the initial volume of the gas before the change was done at constant temperature.
7. About 6 litres of oxygen gas is collected at 300K. If for a particular use, the volume has to be reduced to $\frac{1}{3}$ of its original volume, find the temperature to which the gas has to be cooled ? [Pressure is kept constant]

II. Four alternatives are given to each of the following incomplete statement / question. Choose the right answer :

1 The expression which do not says relation between volume and temperature, at constant pressure is

a) $V = KT$

b) $T = \frac{V}{K}$

c) $V/T = K$

d) $V = K/T$

2. The temperature which also called Absolute Zero is

   a) 0 °C   b) 0 °F

   c) – 273 °C   d) – 273 K

3. The relation between volume and pressure of a gas at constant temperature is

   a) P/V = K   b) T = PV

   c) V/P = K   d) PV = K

III. Fill in the blanks

1. Under constant pressure, per degree rise in temperature, the volume of gas is increased by ______________ of the original volume at 0 °C.
2. The SI unit of temperature is ______________
3. The volume of gas diffusing per unit time is ______________

IV. Match the following

A	B	C
1. Charles Law	i) $\frac{\text{Volume of gas diffused}}{\text{Time}}$	a) TV = PK
2. Boyles Law	ii) Constant volume	b) V = KT
3. Rate of Diffusion	iii) Constant temperature	c) PV = K
	iv) Constant pressure	d) $r = k\sqrt{\frac{v}{m}}$

CHAPTER 19

PLANT AND ANIMAL BREEDING

After studying this chapter you

- know about various plant breeding techniques.
- identify various hybridization techniques employed in plant breeding.
- understand and appreciate the role of biotechnology in plant and animal breeding.
- realise the need for the application of biotechnology in food industry.
- analyse the relative merits and demerits of developing genetically modified plants and animals.

You are already aware that food is the basic need of all living organisms. Apart from being the source of energy, food is required for development, growth, and repair of the worn out tissues. Hence, every living organism will have developed a mechanism, either for manufacturing food or for obtaining it from the surrounding environment.

How was the early man getting food? He was a **food gatherer**, depending on plants and animals. He led a nomadic life in search of food. Gradually, he became a **food grower**. It is believed that the cultivation of food plants, **crop plants** as they are called now, must have begun in the middle stone age, around 10,000 B.C. Besides growing food plants, he is also said to have started breeding animals.

Know this

What are food crop plants?

Plants which are grown and cared in the fields, to serve as food or as a source of any food product, and harvested seasonally are called food crop plants.

Crop plants are classified on the basis of the products obtained from them.

Activity 19.1

One example for each type of crop plant is given in the following table. Think of other examples and add them to the list.

Table 19.1 Types of crop plants

Sl.no.	Crop type	Example	Additional examples
1.	Cereals	Paddy (rice)	
2.	Pulses	Beans	
3.	Spices	Pepper	
4.	Beverages	Coffee	
5.	Oil crops	Ground nut	
6.	Sugar crops	Sugar cane	
7	Fibre crops	Cotton	
8.	Plantation crops	Coconut	
9.	Root crops	Carrot	
10.	Tuber crops	Potato	

You know that food crops are also classified into two types based on the season of cultivation or harvesting, namely;

- **Kharif crops** they are raised in rainy seasons and harvested at the end of monsoon season. (during September and October).
- **Rabi crops** they are raised in winter season and harvested in the summer(during March and April).
- From times immemorial, man has been attempting to improve the yield of crop plants. This has led to the practice of **plant breeding**. Conventional plant breeding practices involve developing new varieties of plants to suit varying climatic conditions, to improve taste or nutritional value, to equip the plants to cope better with diseases and pests and to make them use water and nutrients more efficiently.

Conventional plant breeding, requires a crossing of two closely related plants. The aim is to combine the favourable traits from both the plants and eliminate their unwanted traits. This results in the formation of a better and a new variety of plant. The term **variety** is used to describe a group of plants similar in their gene composition, but differing in a few characteristics.

Following are the procedures followed in conventional plant Breeding.

1. Selection : it is the most ancient and basic procedure in plant breeding. It is a process where a breeder selects from a population of plants having desirable characteristics. Only the seeds from selected plants are used to raise the next generation. Rest of the plants are generally rejected.

2. Hybridization: it is the most commonly employed technique in plant breeding. The aim here, is to bring together desired traits through cross pollination.

- Most often different varieties of the same species are mated. For e.g. Different varieties of wheat have been mated to obtain some new varieties. This is called **intervarietal hybridization**.
- Sometimes a crop species is mated with a different, but related species. This is called **interspecific hybridization**. For e.g. All the sugarcane varieties grown today are interspecific hybrids.
- Very rarely, a mating can be conducted between members of two related genera to get a totally new kind of plant. This is called **intergeneric hybridization**. For eg. a species of wheat, Triticum turgidum has been cross bred with a species of rye, (*Secale cereale)* to get a new variety of plant called **Triticale.**

3. Polyploidy : Most plants are **diploid (2n)** in nature, carrying a double set of chromosomes. Plants with multiple sets of chromosomes are called **polyploids**. The technique of developing polyploids is called **Polyploidy.** It can be 3n, 4n, 6n and so on. Increase in the chromosome sets per cell can be artificially achieved by a chemical called **colchicine**.

Know this

Colchicine used for inducing polyploidy is obtained from a plant called ***Colchicium autumnale****, a member of the onion family.*

- Polyploid plants are bigger in size and show greater genetic variability. However, in such plants fertility is lower and growth is very slow.

4. Induced mutation: Genetic changes can be brought in a plant by using certain agents called **mutagens**. These may be chemicals or radiation. The resulting plants called **mutants**, are tested and selected for favourable traits. Over 200 varieties of crops have been developed in our country using mutation breeding. However this method is not widely used, since the site of mutation in the gene cannot be controlled.

Activity 19.2

High yielding varieties of wheat and rice were extensively cultivated in the Asian countries in 1960s leading to the ***green revolution****. But it has caused degradation and loss of soil, along with several severe environmental problems. Find out the reasons.*

Role of biotechnology in plant breeding

In the recent years, plant breeding involves changing the genes of a plant by genetic modifications using certain sophisticated techniques. The growth of biotechnology has paved way for a direct manipulation of the genes in plants, instead of mixing the genes randomly as in conventional methods.

One major aspect of biotechnology is the practice of growing plant cells and tissues in a suitable culture medium, under controlled laboratory conditions. It is called **tissue culture**.

Tissue culture is the practice of growing an entire plant from a single cell or a tissue, under aseptic, laboratory conditions. Plant parts like anthers, embryos, ovaries and shoot tip (meristem) can be cultured. Cell culture and protoplast cultures are very common. The basis for tissue culture is the **totipotency** of plant cells.

Know this

Totipotency is defined as the capacity of a cell to differentiate into a new organism.

- Tissue culture is extensively used for large scale propagation of medicinal and ornamental plants
- It is also used for propagating crop and forest plants.
- Tissue culture is also used for developing disease-free plants.
- Cell culture is used particularly, for the extraction of many useful **metabolites.**
- Another major development in plant breeding is the modification of genes in a plant. Instead of randomly mixing genes as in conventional plant breeding, a specific gene responsible for a desired trait, is selected and introduced directly into the new plant variety. This is called **genetic modification**. Such plants are called **genetically modified plants** or **transgenic plants**. Genes from unrelated plants and even other organisms can be used for a wider choice of genetic diversity. It is done by using the **recombinant D N A technology**.

Know this

Recombinant D N A technology involves manipulation of genetic material of an organism under laboratory conditions. In this technique, the D N A containing the desired gene, is isolated from a cell of its normal occurrence. It is then transferred into a new host cell with the help of a carrier D N A called vector D N A.

Following are some examples of genetically modified plants :

Sl. No.	**Traits/products**	**Plant examples**
1.	Herbicide resistant	corm, potato, tomato, tobacco, cotton
2.	Pest resistant	corn, cotton, potato, tomato
3.	Virus resistant	papaya, cucumber, water melon, tomato, potato
4.	Modified ripening	tomato **(flavr savr)**
5.	Nitrogen fixation	leguminous plants
6.	Vitamin A enriched	golden rice

A classical example of a transgenic plant is the **Bt cotton**. It is a new variety of cotton in which a gene isolated from a bacterium, called *Bacillus thuringiensis*, has been newly introduced. This gene is responsible for producing a toxin which can kill the boll worms that attack the cotton plant. Thus, the plant is free from boll worm infestation.

Activity 19.2

Collect information on transgenic varieties of food crops. Find out whether it is safe to use such foods. Conduct a debate in your class.

Hydroponics

You must have seen in some houses a plant called Epiremnum aureum (money plant) being grown in a bottle containing water. Can you imagine growing land plants without soil? Yes, it is possible. There is a practice of growing plants in mineral nutrient solutions in water, without soil. It is called **hydroponics**. It is based on the idea that when the required mineral nutrients are directly introduced into the supply system of a plant artificially, soil is no longer required for a plant to survive.

In this method, terrestrial plants are grown by immersing their roots in nutrient solutions in specially designed containers. Almost any terrestrial plant can be grown with hydroponics.

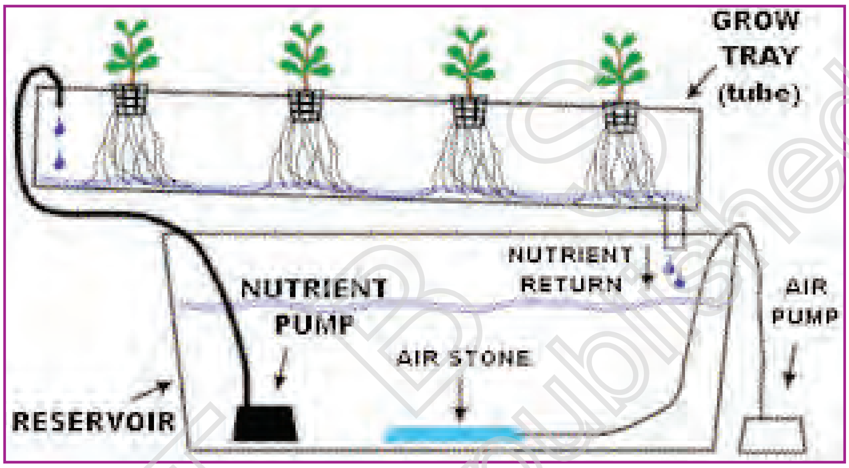


Fig. 19.1 Hydroponic system

Following are some advantages of hydroponics

- Soil is not required.
- Water requirement is very less.
- Yields are stable and high.
- There will be no weeds to remove.
- Plants grow much healthier.

However, the only disadvantage with hydroponics is that it leads to rapid plant death.

Aeroponics

It is a form of hydroponics where the roots of a plant are either continuously or discontinuously kept in an environment saturated with fine drops of mineral nutrients. Plants can also be grown with their roots suspended in air. Alternatively, the plants can be grown in a green chamber with excellent aeration. The roots hang in air and are sprinkled with nutrient solutions every now and then. Potato, tomato and many leafy vegetables are being grown using this method.

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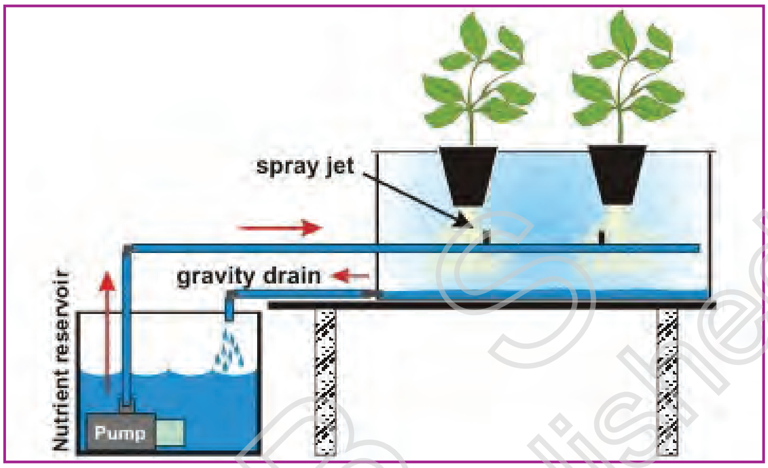


Fig. 19.2 Aeroponic system

Hydroponic and aeroponic methods are of significance for space research organizations, in developing special kinds of foods for astronauts. It is because a mist is easier to handle in zero-gravity situations, than a liquid. Hence, these two fields are gaining significance in developing space foods.

Roof-top gardening

You would have seen some houses where people have grown a nice garden on the roof of their houses. It is now becoming a trend in urban areas where sufficient space is not available for growing plants of their choice. Besides plants of ornamental value, even vegetables and some food crops can be grown on roof tops.

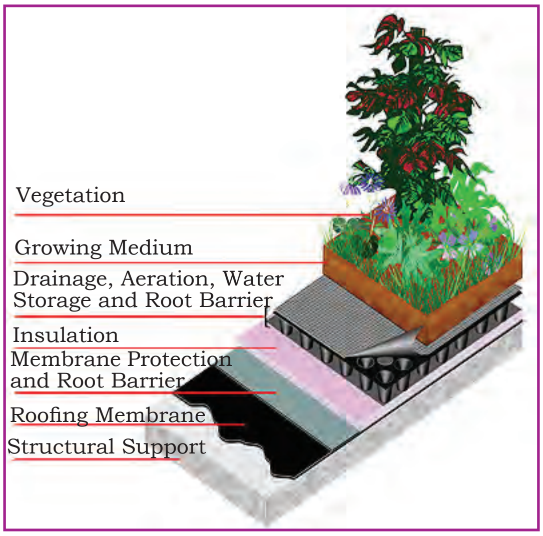

Vegetation
Growing Medium
Drainage, Aeration, Water Storage and Root Barrier
Insulation
Membrane Protection and Root Barrier
Roofing Membrane
Structural Support

Fig. 19.3
Roof top gardening system

Roof tops are one of our greatest resources in our crowded cities and towns, for growing plants. With some technical assistance which is easily available, any person can take up the practice of roof-top gardening. It requires some precautionary steps which prevent the roof from becoming leaky due to seepage of water. In addition, measures are to be taken to enable the roof to bear the additional weight of plants and soil.

There are some specific benefits from roof-top gardening :

- It increases access to safe outdoor green space.
- It improves air quality due to increased absorption of carbon dioxide.
- It provides habitat for butterflies and birds.
- It becomes a source of recreation.
- It encourages urban food production.

More than these ornamental and utility aspects, it provides a temperature control mechanism, by insulating the heat.

Know this

Rooms under a green roof, are 3 to 4 degrees Celsius cooler than the outside air when temperature is in the range of 25 to 30 degrees Celsius.

Animal breeding

Man has been domesticating animals from a long time. Various animals provide important products like food, fur, wool and manure. In addition, animals become useful for activities like agriculture and transport. Just as improvements have occurred in plant breeding, there have been significant improvements with reference to the rearing and care of domestic animals. The various aspects related to feeding, breeding, caring and sheltering of animals in the service of mankind, together constitute **animal husbandry**.

The term **livestock** is used to collectively describe animals domesticated by man for various uses. Cattle, pig, sheep, goat, fowl and duck constitute common examples of livestock. These animals have significant contributions to rural economy. On the basis of their utility, livestock can be grouped as follows:

Table 19.3

Utility	**Example**	Additional examples
Milk yielding animals	Cow	
Meat and egg yielding animals	Fowl	
Animals for agriculture and transportation	Bullocks	
Wool and leather yielding animals	Sheep	
Honey, silk and lac yielding	Honey bee, Silk worm, Lac insect	

Activity 19.4

One example for each type of livestock is given in the table above. Think of other examples and add to the list.

Animal breeding aims at improving the genetic makeup of animals to make them more useful to us. The main objectives of animal breeding are as follows:

- Improving the growth rate
- Increasing the production of milk, meat, egg, wool and other products
- Improving the quality of products
- Improving the resistance to diseases
- Increasing the span of productivity
- Increasing the rate of reproduction

The main approaches for animal breeding are inbreeding, out breeding and hybridization.

- **Inbreeding:** It is the crossing of the male and female individuals of the same species, among the same breeds. Superior males and superior females in the breeds are identified for this purpose.

- **Outcrossing:** It involves crossing of superior males of one breed with superior females of another breed. It allows the desirable qualities of the two breeds to appear in the offspring.
- **Hybridization:** In this approach superior males and females of two different species are mated. The progeny are often different from both the parental species.

For example, in India we come across three different kinds of breeds of cow.

1. **Indigenous breeds :** Sindhi, Sahiwal, Gir, Hallikar
2. **Exotic breeds :** Jersey, Holstein, Brown Swiss, Friesian
3. **Cross breeds :** Karan Swiss, Karan fries, Frieswal, Karan

Following are the steps involved in conventional plant breeding.

Activity 19.5

Try to collect information about all the indigenous breeds of cows and buffaloes of our country.

The conventional selective breeding techniques in animals take a long time to yield the desired results. Just as in plants, certain biotechnological procedures have been extended to animals also. The recombinant D N A technology has been used in animals also to introduce new genes into animals. This has resulted in the arrival of genetically modified animals or transgenic animals. Following are some examples of transgenic animals.

- Introducing certain human gene sequence into Cattle, goat and sheep for enhanced growth, meat and milk production.
- Bacterial genes introduced into sheep has resulted in improved wool output.
- Cattle containing human gene responsible for production of growth hormone, have shown the production of milk containing human growth hormone.

Role of biotechnology in food industry

Another major contribution of biotechnology can be observed in the field of food technology. In the recent years, we are observing significant changes in the food industry especially with reference to increasing the shelf life and nature of food. Many types of substances are being used for this purpose. They are collectively known as food additives. More than 3000 types of **food additives** are in use today.

- **Natural additives** such as extracts from saffron, beetroot plant which is used as a colouring agent.
- **Man made additives** which are synthetic copies of naturally occurring substances, like saccharine.
- **Artificial additives** which are produced synthetically and not found in nature. The most widely used form of food additives are in the form of **preservatives**. These substances basically prevent the growth of microorganisms that cause the spoilage of food. They increase the shelf life of food.

Antioxidants are substances which prevent food containing fat or oil from developing a foul smell

Colourants are substances which restore colour lost during processing of food. They are also used to reinforce the colour already present or add colour to colourless foods.

Flavourants are substances used for adding a particular taste.

Sweeteners are substances added to increase the intensity of sweetness.

Almost all these artificial additives are now being synthesised using recombinant D N A technology.

Know this

Common salt (sodium chloride) is the oldest known food additive. It is used for all kinds of foods. Apart from adding to the taste, it prevents early spoilage of food. It also makes water unavailable to microbes. On an average, a man consumes about 10 to 12 g. Of salt every day.

Exercise

I. Answer the following questions

1. What are crop plants? How are they classified? Give two examples for each of them.
2. What is hybridization? Mention its different types.
3. What is polyploidy? What is its importance.
4. What is mutation? How is it caused?
5. What is tissue culture? What are its advantages?
6. What are transgenic plants? What are their relative merits and demerits?
7. What is hydroponics? Make a list of its advantages.
8. What are the advantages of roof-top gardening? What precautions are necessary for this method?
9. What is livestock? How are they grouped? Give an example for each.
10. Mention the three kinds of breeds of cows in India with two examples for each.
11. What are transgenic animals? Give two examples.
12. What are food additives? How are they classified?

II. Name the following.

1. A chemical, used to induce polyploidy.
2. Agents that cause genetic changes.
3. Technique used to obtain genetically modified plants.

4. Carrier gene used to transfer the desired gene in to a new host cell.
5. Substances used to improve the nature of food with an increase in its shelf life.
6. Food additives used to prevent the spoilage of food.
7. Capacity of a cell to differentiate into a new organism.

III. Differentiate between.

1. Kharif crops – Rabi crops
2. Interspecific hybridization – Intergeneric hybridization
3. Mutant – Mutagen
4. Hydroponics – Aeroponics
5. Inbreeding – Out crossing
6. Antioxidant - Colourant

IV. Give reasons for the following.

1. Hydroponic and aeroponic methods are important for space research organizations.
2. Food additives are widely used in modern life.
3. Polyploids have both advantages and limitations.
4. Addition of artificial food additives should be minimized.

* * *

CHAPTER 20

CONTROL AND COORDINATION IN PLANTS AND ANIMALS

After studying this chapter you

- know the process of chemical coordination in plants.
- understand plant hormones, their characteristics and functions.
- analyse chemical coordination in man.
- know the importance of hormones.
- understand the structure and functions of endocrine glands.
- analyse hormonal disorders and their symptoms.
- understand the importance and functioning of nervous system in man.
- know the importance and functions of sense organs.

We see in our surroundings, plants, animals and humans showing different kinds of movements for various reasons. The movement can be of the whole body or any part of it.

Think

- a plant kept in a room bends towards the window.
- a cat chases a rat.
- we close our eyes when there is dust in the air or our eyes produce tears when dust falls into them.
- we withdraw our hands on touching a hot pan.
- when we are hungry, we salivate on seeing a delicious food.
- our heart beat rises suddenly on seeing a snake.

Why should living organisms exhibit movement? The reason would be that every living organism reacts to any given change in its environment, for its survival. You are aware that all living things have a basic tendency of showing responses to changes in the environment. This is called **Irritability**. The changes in the environment are called stimuli. The reaction of organisms to a stimulus is called **response**. This response is usually in the form of movement or secretion of chemical substances by glands. If we think further, we understand that, these movements or responses, are carefully controlled.

Activity 20.1

Make a list of some examples of stimuli and responses shown by organisms.

Sl. No.	Organism (plant/ animal)	Stimulus	Response
1. Eg.	Cockroach	light	Moves away from light
2.			
3.			
4.			
5.			
6.			
7.			
8.			

In any situation, organisms can know about their environment with the help of sense organs and show relevant responses using their muscles or glands. How does this controlled and coordinated process happen in organisms? There must be coordination among various parts in the body which is in turn controlled by another system. This is called **Control and Coordination system**. In plants coordination is brought about by special chemicals called **plant hormones**. In animals, this involves nervous system, Endocrine system, and sense organs.

Chemical coordination in plants

You have observed that the Lotus flower blossoms only when the sun rises and folds itself on sunset, where as the night jasmine blossoms on sunset and folds on sunrise. The roots from the branches of big banyan trees grow towards earth. The tendrils of pepper plants have a spiral or twining movement around a tree during their growth. What makes plants show these phenomena?

Activity 20.2

Select a healthy potted plant. Place it in a cardboard box having a window cut on one side. Observe after 5-6 days. What do you observe? How does the plant respond to this change? Observe the changes, by changing the direction of the box.

Know this

The movement of plants in response to various stimuli is called tropism. Some of the types of tropism are :

1. *Phototropism : response towards light.*
2. *Geotropism : response towards gravity.*
3. *Hydrotropism : response towards water.*
4. *Thigmotropism : response towards touch.*
5. *Thermotropism : response towards temperature /heat.*
6. *Chemotropism : response towards chemicals.*

Plants do not have a nervous system and sense organs like animals. However plants can sense the presence of stimuli like, light, gravity, chemicals, water, soil and respond to them. This is brought about by **plant hormones**. Response in plants is so slow that it can not be observed immediately, but the effect can be seen after some time.

Know this

Plants tend to respond slowly to stimuli. But there are some exceptions.

- Insectivorous plant like Venus fly trap responds very quickly to touch.
- The leaflets of touch me not plant (*Mimosa pudica*) get immediately folded and drooped on touching or vibrations.

Have you observed the phenomena of formation of buds, blossoming of flower, elongation or enlargement of leaves, fruiting, drooping and falling of leaves, ripening of fruits? Usually these happen in accordance with seasonal changes. But some times you can see premature falling of buds, leaves, flowers and fruits. Why does it happen so? This is also due to the release of certain plant hormones.

Think

In villages, farmers keep bananas in the underground chambers of their houses along with half burnt coconut shell that produces smoke. Why?

Know this

Plant hormones *are also called* ***'phytohormones'****. They are organic compounds that are produced in one tissue and translocated to another where they produce their specific effect, and regulate plant growth and development. Hence they are also called growth regulators.*

Types of growth regulators

There are five main types of growth regulators, which can be classified under two categories. They are,

- Plant growth promoters. (Eg. Auxins, Gibberellins and Cytokinins)
- Plant growth inhibitors. (Eg. Abscisic acid and Ethylene)

General functions of auxins, gibberellins, cytokinins and ethylene.

1. Promote cell division, cell enlargement / elongation and cell differentiation.
2. Induce phototropic movement of shoot system.
3. Initiate the development of roots, flowers and fruits.
4. Control the falling of leaf, flower and fruit.
5. Control the premature withering of flowers and fruits.
6. Induce parthenocarpy (development of seed from flower with out fertilization).
7. Break the dormancy of seeds and buds.
8. Delay ageing of leaves.
9. Control the opening of stomata.

Control and Coordination in Man

When you see a dog chasing you, You get frightened and start running away to escape. For this to happen, your eyes must communicate with your leg muscles so that you can run away from it. There must be a communication to the heart to pump more blood and, to the lungs to breathe more oxygen to be supplied to muscles of legs so that you can run fast. How does all this happen?

In human beings, Nervous system and Endocrine system work together in association with sense organs to bring about all activities. The various organs that are present in our body have to work effectively as a team. There is a systematic communication among them.

There are two main ways of transferring information from one part of the body to another. One way is by sending **chemical signals** through the blood and the other way is by sending **electrical signals** through the nerves. The first way includes a group of ductless glands which secrete hormones which is called **Endocrine system**. The second way includes sense organs, brain, spinal cord, nerve, muscles and glands, and they all work together in group as a system which is called **Nervous system**.

Endocrine system

Chemical coordination in animals takes place through chemicals called **hormones**, produced by special organs called **endocrine glands**.

Think

How is a gland different from other organs like kidney or lungs? can you consider stomach, pancreas and intestine as glands?

Know this

Gland : A gland is an organ made up of cells which are specialized for the secretion of particular chemical substances.

Think

We have many glands in our body. Here are a few of them - Salivary glands, pituitary gland, thyroid, parathyroid, stomach, adrenal glands, liver, intestine, pancreas, gonads (testis and ovary). How can you classify them?

Activity 20.3

Observe carefully a chart of anatomy of human body and identify or locate various exocrine and endocrine glands of man.

Hormones

These are special chemical substances secreted in minute quantity by endocrine glands. They are carried by the blood to **targets organs**, on which they act, and coordinate their activities and functions.

Think

*Why are hormones called **chemical messengers**?*

Endocrine system in man

Endocrine system has a number of ductless glands which synthesise, store and release hormones. The major endocrine glands among them are **Pituitary gland, Thyroid gland, Parathyroid glands, Adrenal glands, Islets of Langerhans and gonads (testes and ovaries)**. The position of these glands are shown in the following figure 20.1.

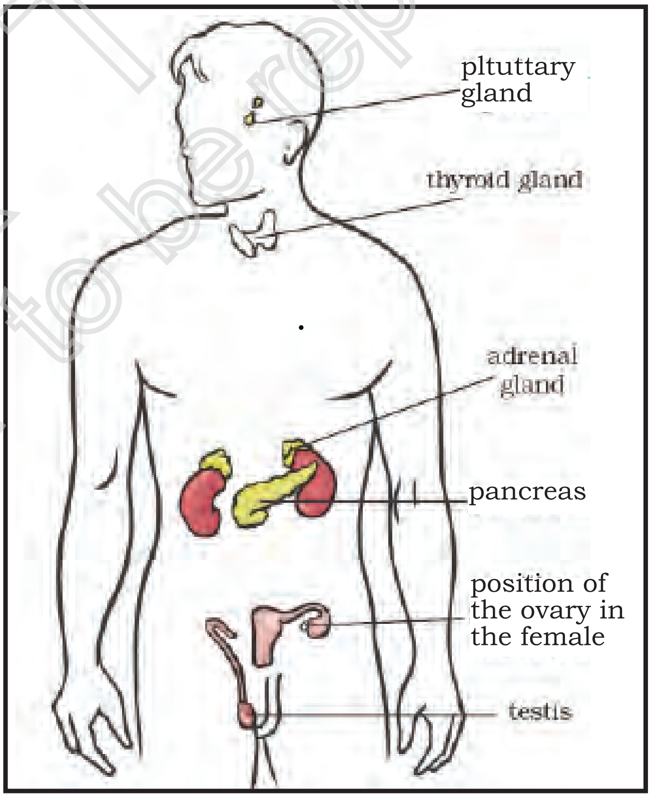


Fig. 20.1 : Location of different endocrine glands in human body

Pituitary gland

The pituitary gland is situated at the base of brain. It has two lobes namely anterior and posterior lobe. This gland secretes many hormones, which control the functioning of other endocrine glands.

Hormones secreted by pituitary gland.

- **Growth hormone (Somatotrophic hormone) (STH)** : It regulates both physical and mental growth
- **Thyroid stimulating hormone (TSH)**: It stimulates the secretion of hormone from thyroid gland
- **Adreno corticotropic hormone (ACTH)** : It regulates the secretion of hormones from adrenal glands.
- **Melanocyte stimulating hormone (MSH)** : It controls the synthesis of melanin in skin.
- **Prolaction** : It stimulates the secretion of milk from mammary glands.
- **Vasopressin** : It controls the excretion of water from the kidneys.
- **Oxytocin** : It stimulates the constriction of uterus muscles during child birth and ejection of milk from mammary glands. It is also called '**birth hormone**'.
- **Follicle stimulating hormone (FSH)** : It stimulates the production of gametes from gonads.
- **Leutinising hormone (LH)** : It stimulates the secretion of sex hormones by the gonads.

Pituitary gland is called the **The conductor of endocrine orchestra.**

When growth hormone is secreted in excess prior to sexual maturity, the growth will be very high and leads to **gigantism**, when it is secreted in less quantity, it leads to **dwarfism**. When growth hormone is secreted in excess even after maturity, it leads to a disorder called **acromegaly**. The symptoms are protrusion of jaws and nose and disproportionate growth of bones in hands and legs.

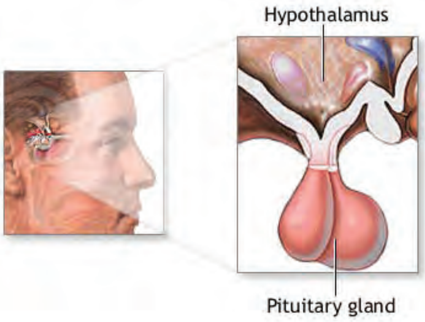


Fig. 20.2 The pituitary gland

Know this

Hyposecretion of antidiuretic hormone (ADH) from pituitary leads to, a disease called diabetes insipidus. The patient passes large quantity of dilute urine, since reabsorption of water in the kidneys has decreased.

Thyroid gland

It is a reddish brown coloured gland present in the throat region, below the pharynx in front of the trachea. It secretes a hormone called **Thyroxin**. It is an amino acid in combination with iodine. Thyroxin influences the rate of metabolism, increases the heat, and promotes the mental and physical development of the body.

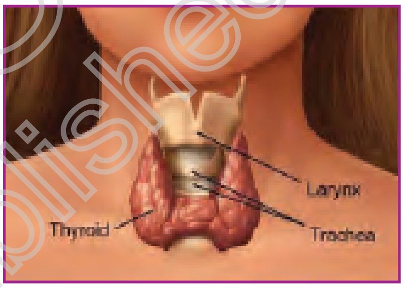


Fig. 20.3
Thyroid gland

Think

Why is Thyroxin called the personality hormone?

People with swollen neck are fairly common in north - eastern part of India. What are they suffering from? It is the symptom of a disorder called **simple goitre** due to deficiency of iodine in the diet. It is an endemic disease. It is restricted to a specific region.

Think

- Usually people living near coastal regions do not suffer from goitre.
- We are using iodized salt for cooking food

Have you seen small children who are mentally retarded with stunted physical growth? Why are they like that? What are they suffering from? They are often called **cretins**. This condition is called **cretinism**. They might have born without a properly functioning thyroid gland. The symptoms of this abnormality are stunted growth, retarded mental development, bow legs, defective teeth, protrusion of the tongue and loose, wrinkled skin with leathery texture.

The underactivity of thyroid gland in adults may lead to low metabolic rate, loss of mental and physical vigor, increase in the body weight, thickening of the skin and lower rate of heart beat. This condition is called **myxedema**. This can be cured by the administration of required quantity of iodine.

What would happen if there is hyperthyroidism? This causes high metabolic rate, protrusion of the eye balls, high blood pressure, nervous tension, irritability, profuse sweating, fatigue and weight loss.

Parathyroid glands

You must have seen some people suffering from painful muscle cramps and some old people who are prone to frequent bone fracture. This is due to the under secretion of a hormone called **Parathormone** by **Parathyroid glands**. There are four small endocrine glands embedded in the tissues of thyroid gland.

The function of parathormone is to regulate the amount of calcium salts in blood and bones. Deficiency of this hormone leads to **painful muscle cramps** and excess secretion of it results in the loss of calcium in bones making them soft and spongy.

Islets of Langerhans

Now a days it has become very common to see people suffering from diabetes. This is due to the under secretion of hormones from **Islets of langerhans**. These are small glands, found inside the pancreas. They secrete two hormones namely **Insulin** and **Glucagon**.

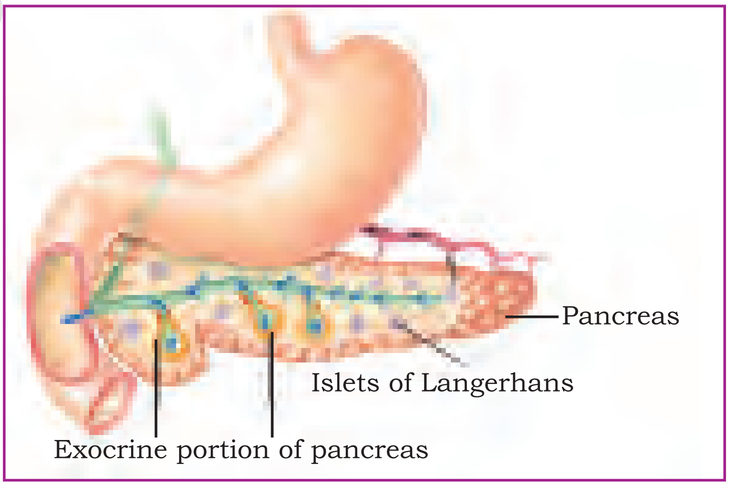


Fig. 20.4
Pancreas with Islets of Langerhans

Insulin promotes the conversion of Glucose into Glycogen, which is stored in liver and muscles. It is secreted in excess quantity when the level of glucose is high in the blood. Undersecretion of Insulin leads to increased level of glucose in the blood that is excreted through urine. This condition is called **diabetes mellitus**. The common symptoms of this disease are increased glucose level in the blood, excretion of glucose through urine, frequent urination, thirst, fatigue and sweating. This disease can be controlled by administering insulin injections.

Think

- Pancreas is considered as a heterocrine gland.
- An endocrine gland which has other endocrine gland in it.
- Exocrine gland which has an endocrine gland in it.

Adrenal glands

When you see suddenly, a truck speeding towards you, what do you do? You get frightened, shout with fear, your heart beat rises, and pupils of eyes dilate, You feel shocked for a while and jump out of the road to escape a possible accident. All your actions have helped you to face this sudden situation. What causes all these responses to happen? It is due to the functioning of Adrenal glands.

Adrenal glands are triangular cap like structures located on the top of the two kidneys. Each gland has an outer **cortex** and an inner **medulla**. Adrenal cortex secretes many hormones. **Cortisone** among them regulates the rate of metabolism and the concentration of salts in the blood.

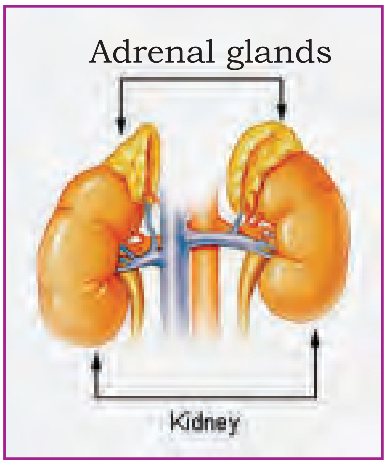


Fig. 20.5 Location of adrenal glands

Adrenal medulla secretes three hormones - **adrenaline**, **noradrenaline** and **dopamine**. Adrenaline regulates heart rate, breathing rate, blood pressure. Normally adrenaline is secreted in very small quantities during normal conditions. But in emergency situations like fear, anxiety, anger and emotional stress, it is secreted in excess and prepares the body to face the emergency situations properly. Hence it is called **emergency hormone.** Adrenaline is also called **fright**, **fight** and **flight** hormone.

Gonads

Boys and girls develop certain specific and differentiating characters at maturity. This is due to the functioning of gonads, which are the sex glands. Gonads produce sex hormones after the attainment of puberty (sexual maturity) in a person. Sex hormones also cause the development of sex organs.

Know this

Male gonad is the **testis** *and the female gland is* **ovary**. *They produce sex cells called* **gametes**. *Male gametes are* **sperms** *and the female gametes are* **eggs**.

Testes produce male hormones called **androgens**. The most common among them is **testosterone**. This hormone is responsible for the appearance of masculine characters in males.

Ovaries produce female hormones called **estrogen**. This hormone is responsible for the appearance of feminine characters in females after puberty. Ovaries also secrete a hormone called **progesterone.** This hormone stimulates the changes in the uterus during menstrual cycle and pregnancy.

Nervous system

Nervous system helps in controlling and coordinating various activities and functions in the body that enable an organism to respond to various stimuli.

What is the importance of nervous system?

- It controls and coordinates various activities and functions of different organs and organ systems in the body.
- It regulates both voluntary and involuntary activities of the body.
- It enables us to adjust to the environment or situation.
- It enables us to think, reason and remember.
- It controls all the reflex actions of the body.

You have already studied that the basic unit of nervous system is the nerve cell or **neuron. A neuron is a special type of cell that is the basic, structural and functional unit of nervous system**. These neurons carry messages in the form of electrical signals called **nerve impulses**. There are three types of neurons. They are **sensory neuron, motor neuron** and **mixed neuron**. A sensory neuron carries impulses from receptors to brain or spinal cord. Motor neuron carries impulses from brain or spinal cord to effectors and a mixed neuron carries both stimulus and response impulses.

Functional components associated with nervous system

The functional components associated with nervous system are receptors, effectors conductors.

The organs that receive stimuli are called **receptors**. Eg: sense organs.

The organs which show visible response are called **effectors**. Eg: muscles and glands.

The tissues which connect the receptors and effectors and help in the transmission of impulses are called **conductors**. Eg: nerves

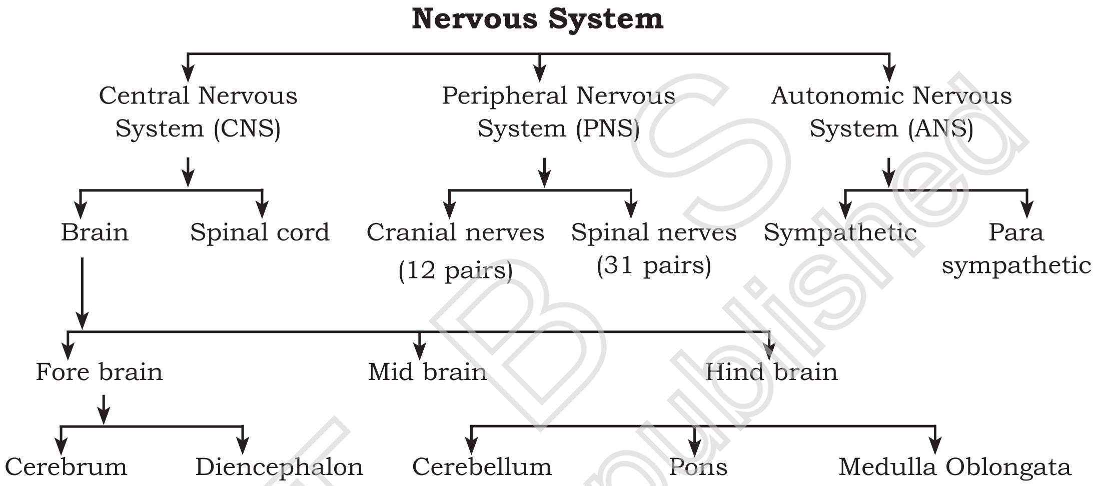
Nervous system in man

We can find three main divisions in the nervous system in man.

- The parts that are present on the central axis are the **brain** and **spinal cord**. They form **Central Nervous System (CNS)**
- The parts that are found on the peripheral region are the nerves arising from brain called **Cranial nerves** and those from the spinal cord are the **spinal nerves**. They form the **Peripheral Nervous system (PNS)**.
- We can also see a network of nerves connected to involuntary organs, controlling and coordinating their functioning, which is called Autonomic Nervous System (ANS)

Central Nervous System (CNS)

The CNS in man consists of the **brain** and **spinal cord**. Both brain and spinal cord are surrounded by three membranes, outer duramater, middle arachnoid and inner piamater. They are together called **meninges**. The space between arachnoid and piamater is filled with a watery fluid called **Cerebro Spinal Fluid** (CSF), that keeps flowing between brain and spinal cord.



Think

What is the advantage of CSF for the brain and spinal cord?

Brain

Brain is located inside the cranium which protects it from injuries. It is the main controlling and coordinating centre of the body. Human brain externally shows three distinct divisions. They are, fore brain, midbrain and hind brain. The hind brain continues into the trunk region as spinal cord.

Know this

The average weight of the human brain is around 1200 to 1400 grams.

Fore brain : It is the most complex part of the brain. It has two main parts **cerebrum** and **diencephalon**.

Cerebrum : It is the largest part of the brain. It is well developed and constitutes nearly 80% of the total size of the brain. The surface of the cerebrum is deeply folded into ridges called **Convolutions**.

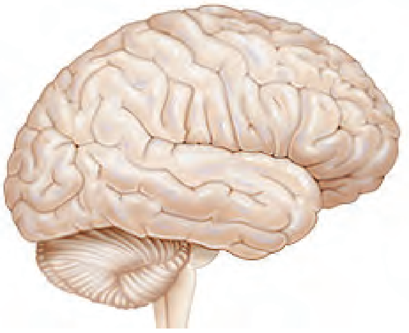


Fig. 20.6 Structure of the human brain (External view)

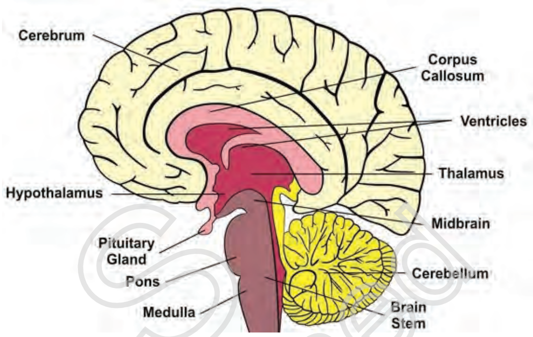


Fig. 20.7 Structure of the human brain (Vertical Section)

Cerebrum has two equal halves called left and right cerebral hemispheres, which are separated by a deep groove. But these cerebral hemispheres are internally connected by a sheath of nerve fibres called **Corpus Callasum**. The nerves from left side of the body are connected to right cerebral hemisphere and nerves from the right side of the body cross over in the neck and are connected to left cerebral hemisphere.

The outer part of the cerebrum is the **cortex** composed of cytons and forms the **grey matter**. Inner region is the **medulla** composed of nerve fibres (axons and dendrites) and forms the **white matter**. The high degree of human intelligence is due to highly developed cortex with more surface area.

The information gained through the sense organs is stored in the cerebral cells and is used whenever required. This is called **memory**. Cerebrum also has centres for intelligence, imagination, emotions, reasoning and will power.

Think

- What makes the cerebrum to have larger surface area?
- Why does any injury to the left cerebral hemisphere result in the paralysis of the organs on the right side of the body and vice-versa?
- Is sharp memory a genetically inherited gift? Can it be enhanced?
- Why is cerebrum called the **seat of consciousness**?

Diencephalon

It is a small area that is covered with cerebrum. It has two parts namely, **thalamus**, that receives nerve impulses from many sense organs and sends them to cortex, and **hypothalamus**. Hypothalamus regulates body temperature, water balance, appetite and sleep. It also controls autonomic nervous system and pituitary gland.

Midbrain

It is a small region of the brain made up of nerve fibres. It connects fore brain and hind brain, through which impulses move from hind brain to fore brain. It is concerned with reflex movements of head and neck in response to visual and auditory stimuli.

Hind brain

It has three parts namely, cerebellum, pons and medulla oblongata.

Cerebellum is the second largest part of the brain. It lies below and behind cerebrum. It controls and coordinates the movement of muscles while walking or running. Hence it is responsible for maintenance of the balance of the body.

Pons is situated in front of the cerebellum below the mid brain and above the medulla oblongata. It regulates mastication, facial expression and respiration.

Medulla oblongata is the posterior most part of the brain and continues as spinal cord into the trunk region. It is concerned with involuntary activities like breathing, heart beat, movements of the digestive tract (swallowing, coughing, vomiting). it is also involved in the secretion of enzymes and maintaining blood pressure.

Know this

- A human brain makes up about 1.9% of total body weight, but it requires 20% of the total blood supply.
- The brain wight of stegosaurus (Dinosaur) was only 0.004% of its body.

Spinal Cord

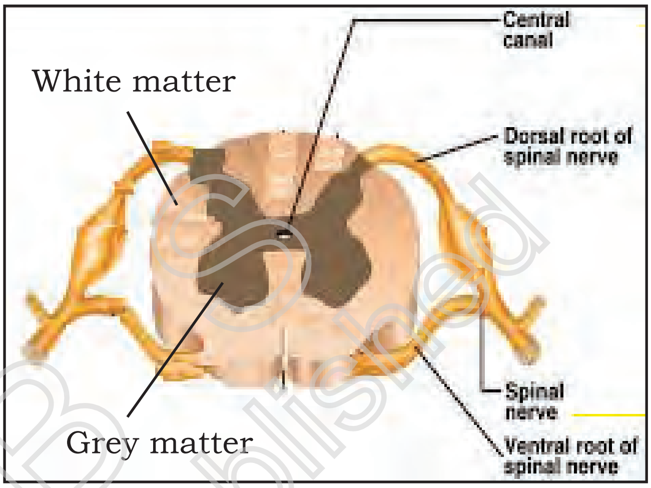


Fig. 20.8
Cross section of the spinal cord

Spinal cord is a long and cylindrical structure that passes through the vertebral column. It is the extension of medulla oblongata into the trunk region. Spinal cord is also surrounded by **Meninges**. It is made up of a large number of nerve cells and nerve fibres. It has Grey matter in the centre, surrounded by white matter.

Spinal cord gives rise to **thirty one pairs of spinal nerves** which branch out to reach many organs in the trunk region like heart, lungs, stomach, urinary bladder and sex glands. These spinal nerves are made up of both sensory and motor nerve fibres. Spinal cord is concerned with the coordination of movements of limbs and organs in the body by reflex actions. It is the centre of **reflex actions**.

Reflex Action and Reflex Arc

Unknowingly, when you touch a hot pan or a hot iron box, how do you respond? You will scream and withdraw your hands immediately. Is it a voluntary or involuntary response? Why is the time taken for showing the response very less? This kind of sudden and involuntary response is called **Reflex action**. The whole process is under the control of spinal cord.

Activity 20.4

In examples similar to one given above, try to track the pathway of the transmission of stimulus and response impulses. Try to identify the receptors, conductors (different types of nerves) and effectors.

This pathway of nerve impulses involved in the reflex action is called the **reflex arc**. This involves conduction of impulses from receptors to the spinal cord and then to effectors.

A reflex arc consists of five distinct parts,

- A **Receptor**, which receives the stimuli.
- A **Sensory neuron**, (afferent neuron) that conducts the stimulus impulse from the receptor to the spinal cord.
- An **Association neuron**, which transmits the impulse from the sensory neuron to the motor neuron.
- A **motor neuron** (efferent neuron) which conducts response impulse from spinal cord to the effectors.
- An **Effector**, which shows the sudden response.

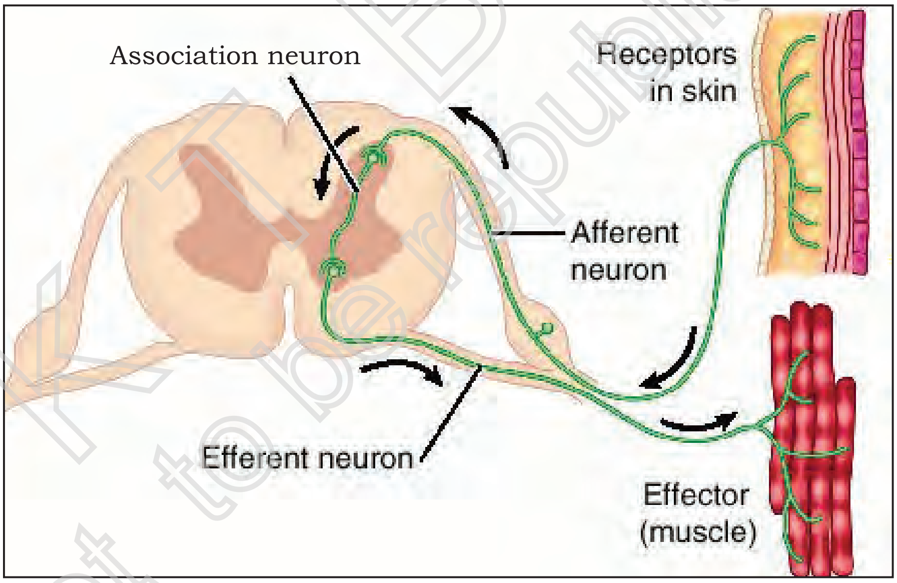


Fig. 20.9 Reflex arc

Peripheral Nervous System (PNS)

All the nerves of the body together make up the Peripheral Nervous System. It includes **12 pairs of cranial nerves and 31 pairs of spinal nerves** which are distributed throughout the body.

Autonomic Nervous System (ANS)

We have certain organs which are not working as per our will. They are functioning on their own. These organs are the involuntary organs.

But their functioning must be under the control of some nerves. These involuntary organs are connected and controlled by a set of peripheral nerves. This is called, autonomic nervous system.

Activity 20.5

Make a list of a few involuntary organs of your body and their functions.

Autonomic Nervous System consists of **Sympathetic** and **Parasympathetic** nervous systems, which control opposite actions of parts or organs in the body. For example, when sympathetic nervous system stimulates the dilation of pupil of the eye, parasympathetic nervous system controls the constriction of the same.

Sense Organs

Any organism can survive in the environment by sensing the changes in the environment through special organs and showing the required type of responses. This is carried out by sense organs.

Activity 20.6

Make a list of the sense organs of man with their respective senses.

Sl. No.	Sense Organs	Senses

There are five sense organs in our body. They are - Eye, Ear, Nose, Tongue and Skin.

Eye

Eyes are the sense organs of sight. They help us to understand the colour, shape, and distance of the object in the presence of sunlight. We have two eyes which are located in the head region, in the front side of the face. Each eye has an eyeball, situated in the bony socket of the skull They are held by muscles which also help in their movement in different directions.

There are some parts associated with our eyes which help eyes in their functioning directly or indirectly. These are called accessory parts of eye. Some times our eyes secrete tear. Where are these tears secreted from? We have tear glands called **Lacrymal glands** which are situated on the inner surface of the upper eyelids. There is a thin and transparent membrane covering the entire front part of the eye called **Conjunctiva**. This protects the cornea of the eye ball.

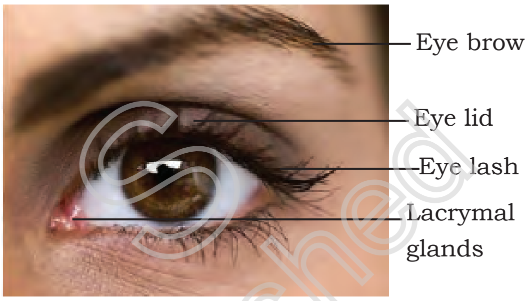


Fig. 20.10
Accessory parts of human eye

Think

What causes eyes to produce tears? Why are tears saline? How are tears useful to eyes?

Activity 20.7

Using a mirror observe carefully the different accessory parts of your eyes. Mention them with their respective functions in the table.

Sl. No.	Accessory part	Function
1		
2		
3		
4		

Structure of human eye

Observe the diagram of the vertical section of human eye(fig 20.11). You will see that the eye ball is spherical and its wall consists of three layers. They are Sclera, Choroid and Retina.

The outer most layer of the wall of the eye is called **Sclera**, which is white in colour, thick and opaque, made up of fibrous connective tissue. The bulged , thin, transparent front part of sclera is called **Cornea**.

The second and middle layer is the Choroid, which has black pigment and is richly supplied with blood vessels and nerves.

Think

What would be the function of choroid as it is thick and rich with blood vessels?

Choroid completely encloses the eye except in the center of the front side. In front of choroid is an opening called **Pupil**, through which light enters the eye ball. We see people with different coloured eyes like brown, black, grey, some times blue and even green. Why is this due to? Choroid forms a muscular layer around the pupil in front of the eye ball. This is called **Iris**. Iris has pigment cells that are responsible for different colours of the eyes.

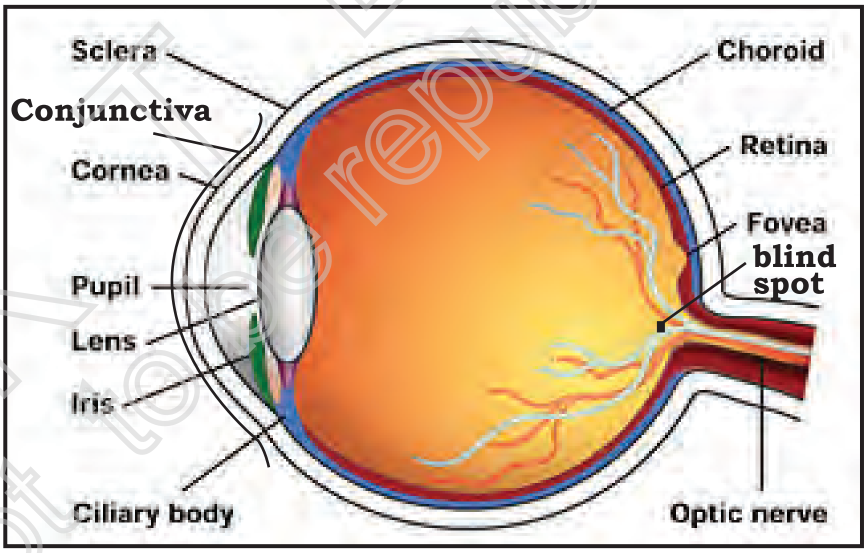


Fig. 20.11 Vertical section of the human eye

The innermost layer of the eye is **Retina**. It has the visual receptors namely, rods and cones. **Rods** are sensitive to dim light and can not differentiate colours, where as **Cones** are sensitive to bright light and can differentiate colours.

The distribution of rods and cones in retina is not uniform. A large number of cones are located opposite to the pupil at a depressed point on retina and this is called **Fovea (yellow spot)**. This is the region where a distinct clear image is formed. All the sensory nerves of retina form a bundle called **Optic nerve** that leaves the eye ball just below fovea. Here there are no sensory cells and hence no image is formed. This part is called **Blind spot**. Optic nerve is the sensory nerve of the human eye, which carries the visual impulses to the cerebrum of the brain.

Eyes have a transparent **convex lens** in the front side behind the pupil. It is held in position by suspensory ligaments and ciliary muscles. These ciliary muscles by their contraction and relaxation help in regulating the convexity of the lens as per the distance of the object from the eye.

The small space between the lens and the cornea is filled with a transparent and thin fluid called **aqueous humour**. Behind the lens there is a large space which is filled with a thick fluid called **vitreous humour**.

Think

- When we suddenly enter a cinema hall, initially we will not be able to see any objects. Our eyes take some time to adjust. After some time things become clear. Why is it so?
- How can pupil help eyes to adjust when there is dim or bright light?

Functioning of the human eye

Light is necessary to see any object. The reflected light rays from the object enter the eye ball through the conjunctiva, cornea, pupil and lens and get focussed on the fovea of retina to form a small, real and inverted image. The visual receptors (rods and cones) get stimulated by **photochemical reactions** and convert these images into electrical impulses. These impulses are carried through the optic nerve to the visual centre where they get interpreted. It results in vision.

Activity 20.8

Stand near a window and see an object that is very close to your eye as well as an object which is very far away from your eye. Can you see both of them clearly.

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The human eye has the capacity to see both nearer and farther objects clearly. This is due to the adjustibility of the lens to alter its focal length in order to focus the light rays on the fovea of the retina. When we see a distant object, the convexity of the lens decreases and the eye ball becomes flat. On the other hand, when we see a nearer object, the convexity of the lens increases and the eye ball gets bulged. This capacity of the lens is called **accommodation of the eye**.

Think

Do you have the habits of :
- *reading books during long road journeys?*
- *holding books very close to your eyes while reading?*
- *reading books in dim light?*

What would these habits lead to regarding your eyes?

Common defects of human eye

You have seen some of your friends or neighbors wearing spectacles. Your parents or grand parents may also be using them. Why do they use spectacles? They may be suffering from some defects or disorders of the eye. Can these defects be accurately diagnosed and corrected?

Have you seen any person who is able to see the nearer objects clearly but not the distant objects? The distant objects appear blurred. This condition is called **Myopia (Short sightedness)**. In this case, the image of the distant object is formed in front of the retina due to the bulging of the eye ball or increasing of the convexity of the lens. This defect can be corrected by using a concave lens of a suitable focal length. (Power of the glasses used is mentioned in minus(-).

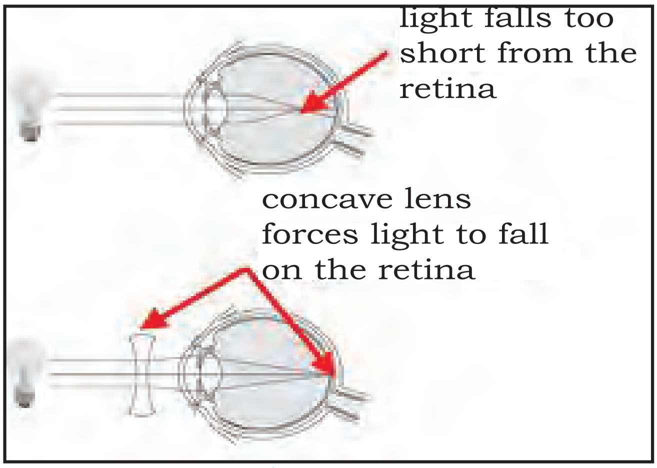

light falls too short from the retina
concave lens forces light to fall on the retina

Fig. 20.12
Myopia and its correction

Have you seen any person who can see the distant objects clearly but not the nearer objects? Nearer objects appear blurred. This condition is called **Hypermetropia (Far sightedness)**. In this case, the image of the object is formed behind the retina due to the constriction of the eye ball or decreasing of the convexity of the lens. Why is this condition due to? This condition may be due to old age or malnutrition of the eye.

In some aged people, there may be a defect related to accommodation of the eye. The lens may loose its elasticity. The lens becomes rigid and results in a kind of farsightedness. This condition is called **Presbyopia**. This can also be corrected by using convex lens.

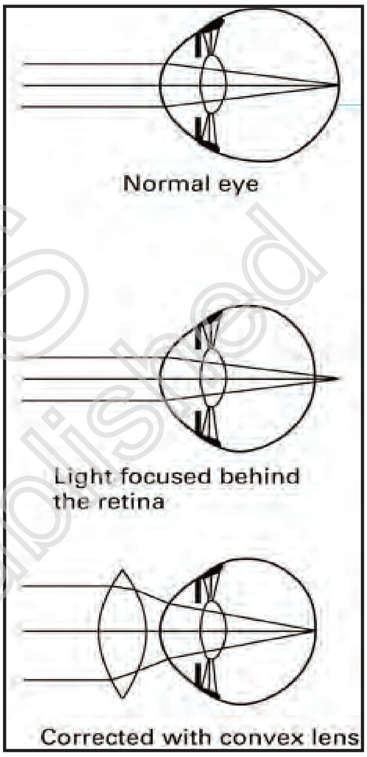


Fig. 20.13 Hypermetropia and its correction

You might have heard some old people or your grand parents complain of blurred vision. They often say that there is a layer formation in the eye. This condition is called **Cataract**. It is condition in which the transparent lens of the eye becomes opaque. This can be rectified by replacement of opaque lens or cornea by an artificial one.

Think

Importance of eye donation

The whole eye or cornea of the eyes from the dead body of a man can be removed, stored and grafted to a needy man.

Do you know that the eyes donated by a man can give sight for two blind persons. The eyes can be taken from the body of a person within a maximum of six hours after death and can be stored in eye banks. Later they can be successfully grafted to a needy person. You can also register your name for your eye donation in an ***eye bank****. We can see even after our death!*

Activity 20.9

Consult an optician or an eye surgeon and collect information about cornea banks and cornea grafting.

Diabetes retinopathy

You have heard that diabetes is a harmful disorder. A patient suffering from long term diabetes, may lose eye sight. The cause for this is **diabetes retinopathy.** In this disorder, blood capillaries in the retina may rapture causing blood entering the **vitreous humour** and making it opaque. This leads to blindness. This disorder can be cured by laser treatment or a surgery called **vitrectomy**.

Astigmatism

It is a condition in which, in some people, a part of the image formed on the retina is blurred due to unevenness of the refractive surfaces of the eye such as lens or cornea. This condition is called **Astigmatism**. This can be corrected by using suitable **cylindrical lenses**.

Some people who are aged above 40-45 years may be suffering from a serious disease of the eye which would often lead to total blindness. This is called **Glaucoma**. The person suffering from this disease may first see flashes of light and coloured rings around the object. Why is it due to? This is mainly due to gradual hardening of the eyeball. This can be cured in early stages by medicines and in advanced stages, a surgery may be required.

Know this

Some persons may fail to identify the colours of the traffic signal lights. The reason for this is colour blindness. This is a genetic disorder in which a person is unable to differentiate colours like red and green.

Think

Can colour blindness be corrected?

First aid for the removal of foreign bodies in the eye

Foreign bodies such as flies, dust particles, pieces of metals or wood may enter the eye. In such cases, eyes should not be rubbed which would further worsen the condition. If the foreign body is visible, it can be removed using clean hand or a piece of cloth. It can also be removed by continuously blinking the eyes for some time in a bowl of clean water or boric solution.

Activity 20.10

Blindfold yourself and try to move or work at home for sometime. You will realise how important our eyes to us.

It is indeed very important to take care of our eyes and avoid any conditions that would finally lead to blindness.

Care of the eyes

- Do not strain eyes by reading books with very small letters in dim light for long time.
- Do not read books during journeys on roads.
- Avoid direct bright light.
- Eyes should be washed with clean and cold water at least twice a day.
- Avoid watching television from a very short distance for a long time.
- Avoid working on computer with monitor for a long time.
- In any case of emergency, consult the eye specialist. Avoid self medication.

Ear

Ear is the sense organ of sound. In man, ears are situated on either side of the head and are responsible for hearing and maintenance of the balance of the body. Ear has three parts namely, **outer ear**, **middle ear** and **inner ear**.

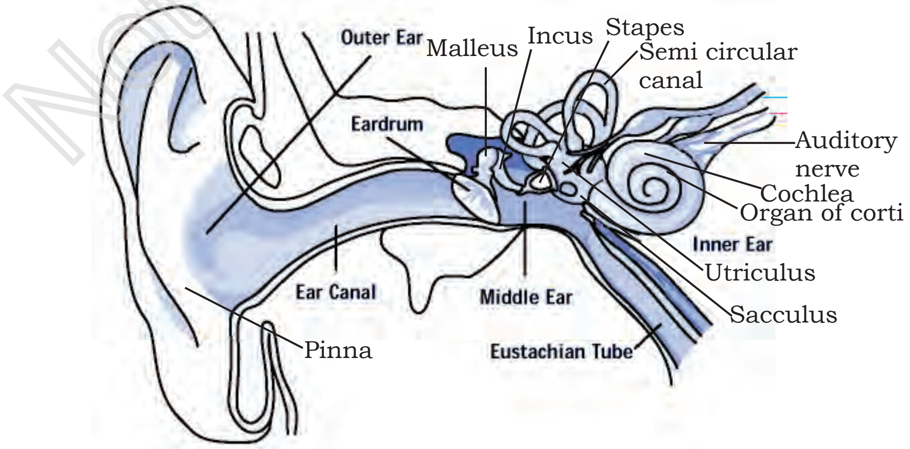


Fig. 20.14 Internal structure of human ear

Activity 20.11

Observe silence and try to listen to sound from different sources. Try to recognise these sounds.

The outer ear consists of **ear lobe** (pinna) and **auditory canal**. Ear pinna or ear lobe is made up of cartilage.

Think

Why do you think that pinna is immovable in human beings unlike in most other mammals?

Auditory canal is a small tubular structure with hairs and wax secreting cells. Auditory canal leads to the middle ear. The middle ear is a very small region consisting of **tympanum** (eardrum) and a chain of three very small bones (ossicles) namely, **malleus (hammer)**, **incus (anvil)** and **stapes (stirrup)**. The vibrations in the form of sound impulses from the tympanum will pass through the malleus incus and finally stapes and then to the inner ear by coming in contact with the **oval window (fenestra ovalis)**. The middle ear is connected with the throat region through a tubular passage called **eustachian canal**. This helps in equalising the air pressure on either side of the ear drum.

The inner ear is a delicate part, enclosed in a bony cavity of the skull. The entire inner ear is filled with a fluid called **endolymph** and surrounded by another fluid called **perilymph**.

Think

What is the advantage of fluids filling the spaces of the inner ear?

The inner ear has two main parts namely upper **utriculus** and lower **sacculus**. The utriculus leads to a set of three **semicircular canals** and sacculus leads to a coiled or spiral structure called **cochlea**. Semicircular canals and cochlea are concerned with the balancing of the body.

Know this

A strong blow on the ears is very dangerous as it would damage the semicircular canals and cochlea. This would lead to leakage of fluids and some time even to death, with ear bleeding.

Cochlea occupies a large space in the inner ear and encloses a very delicate structure called **organ of Corti**. It has sound receptor cells. All these cells connect to form the sensory nerve of the ear called **auditory**

nerve. Auditory nerve carries the sound impulses to the auditory centre of the cerebrum.

Think

When there is a severe throat infection, we normally get ear pain. Why?

Mechanism of hearing

The sound waves from the source are directed by the ear pinna to the eardrum through the auditory canal. The eardrum vibrates and these vibrations are transmitted to the inner ear through the chain of bones of the middle ear. The vibrations are further transmitted to the organ of corti of the cochlea through both perilymph and endolymph. The receptors present in the organ of corti absorb these sound impulses which are then carried by the auditory nerve to the auditory centre of the cerebrum. Here they are interpreted and sound is heard.

Think

After getting down from the merry-go-round we lose our balance for a while Why?

Spin your body yourself for sometime. You feel imbalanced for a short time even after you stop. Then slowly you regain balance. Why?

Some People have the problem of air sickness, sea sickness or car sickness, What would be the reason?

Care of the ears

- Wax produced in auditory canal must be regularly removed using safe ear buds. Sometimes it becomes hard. It should not be removed using hard and sharp objects which may damage the eardrum. Consult the ear specialist.
- Loud noise should be avoided as it may hamper hearing. Plug the ears with soft cotton or use ear plugs.
- Common cold or throat infection some times leads to the infection of the middle ear. Consult the ear specialist.
- Some people are born deaf due to congenital defects. Even old age causes deafness. A hearing aid prescribed by the specialist may correct the condition.
- Small insects or worms entering the ears can be easily removed by filling the auditory canal with lukewarm saline water. Do not use oil.

Nose

Nose is the sense organ of **smell**. It also helps in breathing. It has a pair of nostrils which open into the nasal cavity. The wall of the nasal cavity is lined by epithelial cells with smell receptors. They are connected to the sensory nerve of the nose called **olfactory nerve** which carries the smell impulses to the olfactory centre of cerebrum.

Molecules escaping from the object are carried into the nose through the inhaled air. On reaching the olfactory epithelium, they get dissolved in the mucus and stimulate the olfactory receptors. This stimulation in the form of chemical impulses reaches the olfactory centre of the cerebrum where they are interpreted and smell is identified.

Think

Why does food appear relatively tasteless when one has cold or running nose?

Know this

Certain animals like dogs have better sense of smell. Specially trained dogs are used by police for detection of crime.

First aid

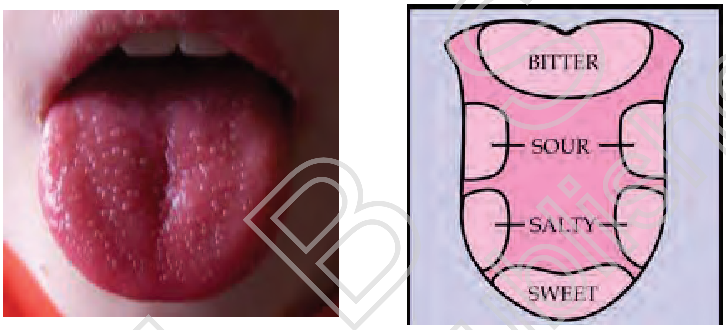
What should be done when an object like bead, button or a seed gets into the nose? The foreign body can be removed by causing violent sneezing using a pinch of snuff. Sharp and hard objects should not be used in this regard which may cause injury to the nose. It is advisable to consult the doctor in extreme situations.

Tongue

Tongue is the sense organ of **taste**. The sensory cells for taste are distributed on the surface of tongue in the form of **taste buds**. They are embedded in the mucus membrane. Each taste bud consists of a group of sensory cells surrounded by supporting cells. The sensory cells are connected to the sensory nerve which carries the taste impulses to the cerebrum which interprets these impulses as taste.

Mechanism of taste identification

When food passes on the surface of the tongue, the sensory cells are chemically stimulated. The chemical impulses are converted into electrical impulses. They are carried by the sensory nerve to the cerebrum of the brain, where taste is interpreted.



Tongue and Distribution of taste buds
Fig. 20.15

What are the different types of taste that we sense in our food? There are basically four types of tastes. They are **sweet, salt, sour** and **bitter**. We detect different tastes of food at different regions of our tongue, since taste buds which find different tastes are located in different regions of the tongue. The taste buds for sweet are located in front; those for salt at anterior edges, those for sour at sides and those for bitter are located in the posterior region of the tongue.

Think

Why do we feel very hot or sensation of pungency when we eat chilly or pepper? Is hotness or pungency a taste?

Activity 20.12

Put some sugar in your mouth. How does it taste?

Block your nose by pressing it in between your thumb and index finger. Now eat sugar again. Is there any difference in the taste?

While taking lunch, block your nose in the same way and notice if you can fully appreciate the taste of the food you are eating.

The skin

Skin is the sense organ of **touch**. It has touch receptors with nerve endings distributed all over it. These receptors sense touch, pressure, pain, heat and cold. Simple touch receptors are present near the surface, pressure receptors are deeper in the skin, and pain receptors are distributed all over the skin.

Think

- What are the functions of skin?
- What makes the skin a sense organ and an excretory organ?

Care of the skin

- Avoid any injury or wound on the skin as it leads to infection. Treat the wound immediately with antiseptic lotions.
- If you get skin diseases like ring worm, consult the dermatologist
- Cover the skin with warm clothing during winter.
- Better to use cotton clothes as they do not cause any skin allergy
- In case of skin allergy in the form of rashes or itching, consult the dermatologist.
- Do not use any type of creams, powder or soaps which are allergic to your skin.

Exercise

Part -1

I. Answer the following questions

1. What are Phytohormones? Give any two examples
2. Enlist any four functions of plant hormones
3. Mention the secretions of pituitary gland with their functions?
4. How is Diabetes mellitus caused? What are its symptoms?

5. What are gonads? What hormones do they secrete? What is their importance?
6. Mention the secretions of Adrenal gland.
7. Why is simple goitre due to? Can it be cured?

II. Name the following

1. Hormone that has Iodine and Amino acids
2. Hormone that stimulates the contraction of uterus

III. Differentiate between the following

1. Exocrine glands - Endocrine glands
2. Androgens - Estrogens

IV. Give reasons for the following

1. Hormones are called chemical messengers.
2. Adrenaline is called the emergency hormone.
3. Thyroxin is called the personality hormone.
4. Goitre is an endemic disease.

V. Match the following

	Column A		**Column B**
1.	Prolactin	a)	Masculine characters
2.	Thyroxin	b)	Concentration of salts in blood and bones
3.	Cortisone	c)	Uterine changes
4.	Parathormone	d)	Secretion of milk
5.	Testosterone	e)	Feminine characters
6.	Progesterone	f)	Physical and mental development

Part -II

I. Answer the following questions

1. What is nervous system? What is its importance?
2. Mention the functional components associated with nervous system.
3. What are meninges? Mention the three layers of meninges
4. Mention the two main parts of fore brain.
5. Mention the four functions of Hypothalamus.
6. Mention the three main parts of the hind brain.
7. What is reflex action? Give an example. What is its advantage?
8. What is reflex arc? Mention its five components.
9. What is Autonomic Nervous System? What are its two main divisions?

II. Draw labelled diagrams of

1. Vertical section of human brain
2. Cross section of spinal cord
3. Reflex arc

III. Name the following

1. The fluid that circulates around brain and spinal cord.
2. The structure that connects the left and right cerebral hemispheres in brain.
3. The bony covering around the brain.

IV. Differentiate between the following

1. Grey matter - White matter.
2. Cerebrum - Cerebellum.
3. Sensory nerve - Motor nerve.
4. Cranial nerves - Spinal nerves.
5. Sympathetic - Parasympathetic nervous system.

V. Give reasons for the following

1. Cerebrum is called the seat of consciousness.
2. A drunkard walks unsteadily.
3. An injury to left cerebral hemisphere leads to the paralysis of parts in the right side of the body.

VI. Match the following

Column A		Column B	
1.	Pons	a)	reflex action
2.	Spinal cord	b)	respiratory centre
3.	Medulla oblongata	c)	pituitary gland
4.	Cerebellum	d)	involuntary activities
5.	Hypothalamus	e)	terminal part of brain
		f)	balance of the body

Part -III

I. Answer the following

1. Make a list of the accessory parts of human eye with their functions.
2. What is meant by accommodation of the eye?
3. What are Myopia and Hypermetropia? How are they corrected? Show with the help of diagrams.
4. Briefly explain the structure of inner ear.
5. Explain the mechanism of taste identification.

II. Draw neat and labelled diagrams of

1. Vertical section of human eye.
2. Internal structure of human ear.

III. Name the following

1. A thin, transparent layer that covers the front part of the eye ball.
2. The light sensitive layer of human eye.
3. The middle bone of the middle ear.

IV. Differentiate between

1. Blind spot - Yellow spot
2. Rods - Cones
3. Endolymph - Perilymph

V. Give reasons for the following

1. It takes sometime to see the objects clearly when we enter a dark room from a bright area.
2. There is no image formation at blind spot.
3. A concave lens is used to correct Myopia.
4. Throat infection often results in ear pain.

VI. Match the following

	A		B
1.	presbyopia	a)	organ of corti
2.	cochlea	b)	cylindrical lens
3.	astigmatism	c)	nose
4.	olfactory nerve	d)	convex lens

CHAPTER 21

HEREDITY

After studying this chapter you

- know the meaning of genetics, heredity and variation.
- analyse Mendel's hybridization experiments using pea plants.
- understand principle and laws of heredity.
- get to know the deviations from Mendelian inheritance.
- appreciate the contribution of biotechnology in modern life.
- explain the contribution of DNA fingerprinting technology in the identification of criminals.
- develop the sense of preserving the balance in nature.

You may have heard people saying, her eyes are just like her mother's, his grandfather had the same kind of nose, she is very tall like her grandmother and so on. You are not surprised if any one resembles his or her parents, but you may wonder how features of grandparents appear in grandchildren without having appeared in the parents. For a very long time many have wondered why inheritance of characters is often discontinuous. How does a feature appear in a later generation after skipping one or more generations? How and where the character is hidden in the intervening generations? Not until the last century answers to these questions were obtained. In the past few decades, we have begun to understand the mechanism of inheritance.

Activity 21.1

Observe the ear lobes of all students in your class. Prepare a list of students having free or attached earlobe. Calculate the percentage of students having each type and collect information about the nature of earlobes of their parents. Correlate the type of earlobe of each student with that of their respective parents. Find out the % of similarities and variations. Based on the data obtained, try to speculate a possible pattern of the inheritance of earlobe types.

We have seen that reproduction gives rise to new individuals that are mostly similar. But there will be some variations. The children of a family are not exactly alike. In a number of animals including human beings, which reproduce sexually, quite distinct variations are visible among different individuals. There may be some patterns of heredity that determine the process of inheritance of characters. These and similar questions are successfully answered by genetics.

Genetics

It is a branch of Biology which deals with a systematic study of Heredity, variations and factors responsible for these. Pioneering experiments in the field of genetics were conducted by **Gregor Johann Mendel**. He is commonly described as **'the father of Modern Genetics'.**

Gregor Johann Mendel (1822-1884) :

Fig 21.1
Mendel

Mendel was born in a poor farmer's family in Austria on 22nd July in 1822. He had his basic education. But could not continue further due to poverty. He was put to a job as a clergyman in a monastery in Brunn. He conducted certain hybridization experiments using pea plants (Pisum sativum) in the backyard of the monastery.

He started his experimental work in the year 1856 and continued for about 14 years. Based on the results of his experiments, he drew some important conclusions and published the same in a journal in 1866. In this paper Mendel proposed some basic genetic principles. But unfortunately his remarkable piece of work went unnoticed for many years probably because the professional biologists of his day could not understand and appreciate his mathematical approach. This neglect of his work and other physical and economic problems made him greatly disappointed. Then his health progressively degenerated and died unknowingly in January 1884.

His research work was rediscovered independently in 1900 by three European genetists namely Correns (Germany), Hugo Devries (Holland) and Tchermark (Austria). They independently drew their conclusions which were similar to those of Mendel. They rewrote his work and published it under the title, Mendel's principles and laws. Later Bateson confirmed Mendel's work through a series of hybridization experiments.

Mendel's experiments

Mendel selected garden pea (*Pisum sativum*) plants for his experiments. Can you guess why he chose pea plants only?

Think

What factors are considered by genetists while selecting organisms for their experiments?

Mendel had the following advantages with pea plants.

1. They can be grown easily in open ground or even in pots.
2. They have a short growth period and life cycle.
3. They give selfpollinating flowers and also it is easy to conduct cross pollination artificially.
4. They produce large number of seeds.
5. They show contrasting heritable characters
6. They produce fertile hybrids on cross pollination.

Fig 21.2 Gregor Mendel conducting experiment

Know this

Heredity : *It is the inheritance of parental characters by their off-springs.*

Variation : *It is the difference in the characteristics of offsprings compared to their parents.*

Think

Why are hereditary variations important?

You have already studied the structure of a typical flower in your previous classes. Flower is the most attractive and reproductive structure of a plant.

Activity 21.2

Observe a Hibiscus flower. Observe carefully the different parts like sepals, petals, pistil, pollen tube, stamen. Using a lens, observe its minute parts like anthers, pollen grains, stigma and ovary. Analyse the structure of each individual part in relation to the reproductive function of the flower.

The main concern of any genetist, while conducting experiments is to observe any variations in the characteristics of offsprings and analyse the factors responsible for the inheritance of these variations. Each character of an organism can have opposite or contrasting forms. For example. (a) The length of the stem has two contrasting forms - **tall** and **dwarf**. (b) The colour of the seed has two contrasting forms - **yellow** and **green**.

Activity 21.3

Observe mature garden pea plants or bean plants. Do you see the following characteristics? If you come across any other such characteristics add to the list. Try to predict their contrasting forms and add to the list.

Sl. No	Character	Contrasting forms	
1	Stem length	Tall	Dwarf
2	Seed colour	Yellow	Green
3	Shape of the seed	Round	Wrinkled
4	Colour of the seed coat	Grey	White
5	Colour of the pod	Green	Yellow
6	Nature of the pod	Inflated	Constricted
7	Position of the flower	Axial	Terminal

These seven characters and their contrasting forms were considered by Mendel for his hybridization experiments. Mendel realised that inheritance can be best understood if contrasting forms of a single character are studied one at a time. For example **tall** and **dwarf** forms of a single character namely, **height** of the plant; the **grey** and **white** forms of the colour of seed coat and so on. He then obtained pure or true breeding varieties of each of the contrasting forms by allowing them to self pollinate for several generations. By this, he got **pure tall** plants whose seeds always produced tall offsprings, **pure dwarf** plants, whose seeds always produced dwarf plants only and so on.

Monohybrid Cross experiments

A cross between two pea plants which differ in one specific character is called **monohybrid** cross. He cross pollinated a tall pea plant with a dwarf pea plant. He repeated the same experiment taking a pea plant with red flowers with another pea plant with white flowers.

He collected the seeds of these cross pollinated plants and sowed them in the next season. He expected the hybrid or crossed plants to be intermediate in their height. But to his great surprise, he found all the plants were tall. He called these hybrids, the F_1 or first filial generation.

In the next season, he planted the F_1 generation seeds. As the plants flowered, he allowed them to self pollinate. When he collected and sowed the seeds, he found a mixture of tall and dwarf plants in the ratio 3:1. He called this, second filial (F_2) generation.

Mendel repeated the same experiment with other contrasting forms of characters. He obtained the same results in the same ratio of 3 : 1 in the F_2 generation. This ratio is called **Monohybrid ratio**.

Mendel then began to analyse and interpret the similar results obtained in all these experiments. He presumed that each contrasting form of a character is controlled by a factor. That is, there should be a factor for tallness, a factor for dwarfness; a factor for producing yellow seeds, a factor for producing green seeds and so on.

In the experiments where the tall and dwarf plants were crossed, the F_1 plants, though all tall, must have contained the factors for both tallness and dwarfness. This is because when F_1 plants were self -

pollinated, the F_2 generation produced some dwarf plants along with tall plants. The factor for dwarfness however remained hidden or concealed in F_1 in the presence of the factor for tallness. Mendel called this factor for tallness **dominant** over the factor for dwarfness, which he called, **recessive**. The F_1 plant had therefore inherited a factor for tallness from its tall parent and a factor for dwarfness from its dwarf parent.

Mendel finally arrived at a conclusion. He stated, ***"When two factors responsible for a pair of contrasting forms of a single character come together, normally one expresses itself, while the other does not". For any given character, there are two forms of factors. One factor is dominant and the other is recessive. This idea is known as the principle of dominance***.

Mendel finally concluded that since the F_1 plants contained two factors for any one character, every individual should also contain two factors for a character, one from each parent. The factors may be of the same type or contrasting types. For example it may be both for tallness, both for dwarfness, or one for tallness and one for dwarfness. Only one factor of a pair of contrasting character was however present in the egg or the pollen.

Gametes	**T**	**t**
T	**TT** **tall**	**Tt** **tall**
t	**Tt** **tall**	**tt** **dwarf**

The checker board method for arriving at the F_2 *generation ratio was first designed by* **Punnet**; *hence, it is also called* **Punnet square**.

It is an easy way of representing the results of a cross, involving contrasting forms.

Phenotypic ratio = 3 : 1

(3 tall & 1 dwarf)

Genotypic ratio = 1 : 2 : 1

(1 pure tall, 2 hybrid tall and pure dwarf)

Dihybrid cross

Mendel also crossed plants with two pairs of contrasting forms such as, a tall plant with red flowers and a dwarf plant with white flowers.

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He crossed the pure varieties of these two types of plants to get F_1 generation in which all resulting plants were tall with red flowers. On self - pollination of the F_1 plants he got the F_2 generation having four types of plants with the ratio **9:3:3:1** as follows.

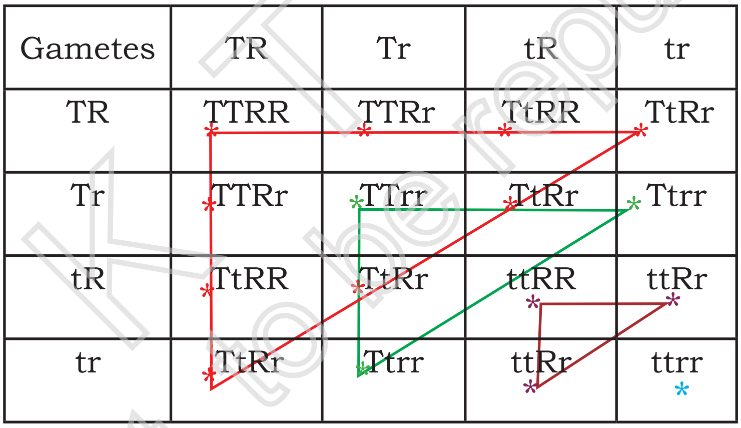
a) Tall plants with red flowers (one of the parental forms)

b) Tall plants with white flowers (intermediate forms)

c) Dwarf plants with red flowers (intermediate forms)

d) Dwarf plants with white flowers (other parental form)

Can you think of such other examples for varieties of plants for dihybrid experiments?



Gametes	TR	Tr	tR	tr
TR	TTRR	TTRr	TtRR	TtRr
Tr	TTRr	TTrr	TtRr	Ttrr
tR	TtRR	TtRr	ttRR	ttRr
tr	TtRr	Ttrr	ttRr	ttrr

* Tall plants with red flowers = 9

* Tall plants with white flowers = 3

* Dwarf plants with red flowers = 3

* Dwarf plants with yellow flowers = 1

Dihybrid ratio = 9:3:3:1

On the basis of results obtained in both monohybrid and dihybrid cross experiments, Mendel formulated the following generalizations which later came to be known as the two basic laws of heredity :

Think

Do you see any relationship between the phenotypic ratio (3:1) of a monohybrid cross and the phenotypic ratio (9:3:3:1) of a dihybrid cross?

1. Law of segregation

The pair of factors for a given character separates in equal ratio at the time of gamete formation during meiosis. It means that a gamete can carry a factor responsible for only one form of a character. Hence this law is also called the **law of purity of gametes**.

2. Law of independent assortment

Factors controlling separate characters normally move independent of each other during gamete formation. So combinations of characters which are not present in the parental forms are produced in the next generation.

Deviations from Mendelian laws

After the rediscovery of Mendelian principles, many genetists conducted hybridization experiments in many different plants. In most of these experiments, the results were similar to those of Mendel. Hence they were called, **Mendelian type of inheritance**. But in a few plants, the results of monohybrid and dihybrid crosses could not be interpreted in terms of Mendel's principles. They showed many deviations from Mendelian inheritance. One such deviation is **incomplete dominance.**

Let us analyse the results obtained by a genetist **Carl Correns (Germany)** who conducted hybridization experiments using the **Four 'O' clock plant (***Mirabilis jalapa***)**. He crossed a homozygous plant with red flowers **(RR)** with another homozygous plant with white flowers **(WW)**. What kind of plants and what ratio do you expect in F_1 generation? Obviously you expect all plants with **red** flowers according to Mendelian principles of inheritance. But for your surprise the F_1 generation produced all plants with only **pink** flowers; So here, there is a deviation from Mendelian inheritance. Why has this happened so?

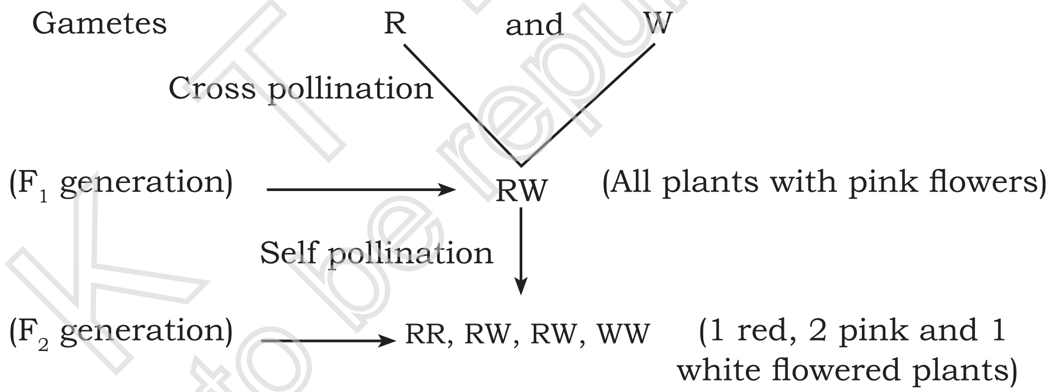
The appearance of pink coloured flowers was an intermediate expression. Further when these F_1 plants were selfed, the plants of F_2 generation showed the similar deviation. Three different types of plants such as plants with **red flowers**, plants with **pink flowers** and plants with **white flowers** were obtained in the ratio **1 : 2 : 1**. This is the **phenotypic ratio**. Note that the genotypic and phenotypic ratio was same.

Schematic representation of Monohybrid cross in 4 'O' clock plant

Factor for red colour of the flower = R

Factor for white colour of the flower = W

Parental generation = pure red flower plant (RR) and pure white flower plant (WW).



Phenotype ratio : 1 : 2 : 1 (1 red, 2 pink and 1 white flowered plants)

Genotype ratio : 1 : 2 : 1 (1 pure red, 2 pink and 1 pure white flowered plants)

Genotypes : RW and RW

Gametes : R and W

Think

Why are the genotype and phenotype ratios one and the same?

This Kind of inheritance deviates from the principle of dominance. However note that it obeys the law of segregation.

The explanation for this kind of deviation was given by Carl Correns as follows. Here the red colour is expressed only in homozygous condition (RR) and the white colour is also expressed only in homozygous condition (WW). But in heterozygous condition (RW) both the genes express. Hence, the intermediate pink coloured flowers are produced. Hence, this phenomenon is called **incomplete dominance.**

	R	**W**
R	**RR** Red	**RW** Pink
W	**RW** Pink	**WW** White

DNA : The basis of heredity

We know that children resemble their parents in certain features and also show some differences or variations. It is very interesting to know how these characters are transmitted from one generation to the successive ones. What carry these characters through generations? What is the physical basis of this transmission?

Activity 21.4

Recall and mention the different parts of the nucleus and their functions.

Sl.No.	**Part**	**Function**
1		
2		
3		
4		
5		

Activity 21.5

- Peel out a thin layer of a fleshy leaf of an onion and observe it under the compound microscope. Do you see compartments or honey comb like structures?
- Make a very thin slice of a fresh stem of a tender plant carefully using a blade under the supervision of your teacher. Put that on a glass slide. Put a drop of red ink on that and observe under compound microscope. Identify the nucleus in it.

Think

Why does the nucleus absorb more colours and look dark?

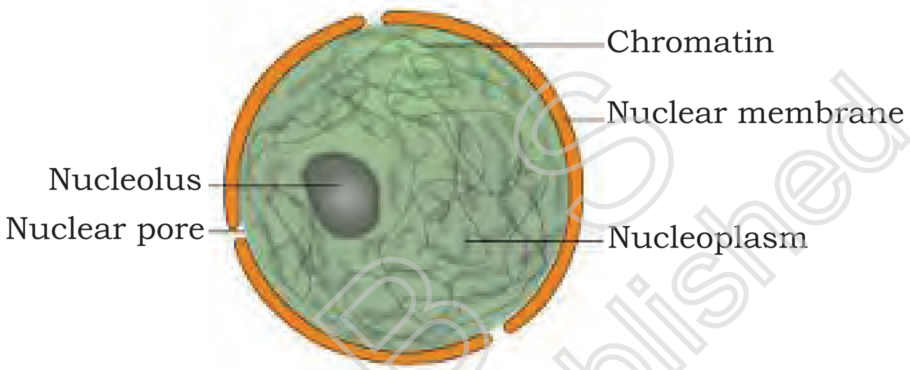


Fig 21.3 Structure of Nucleus

Structure of Chromosome

You have already studied the structure of the nucleus in your previous classes. You can recall that there is a long, diffused and thin thread like structure called chromatin thread or chromatin network in the nucleoplasm. This thin chromatin condenses to become thick and visible **chromosomes** during cell division.

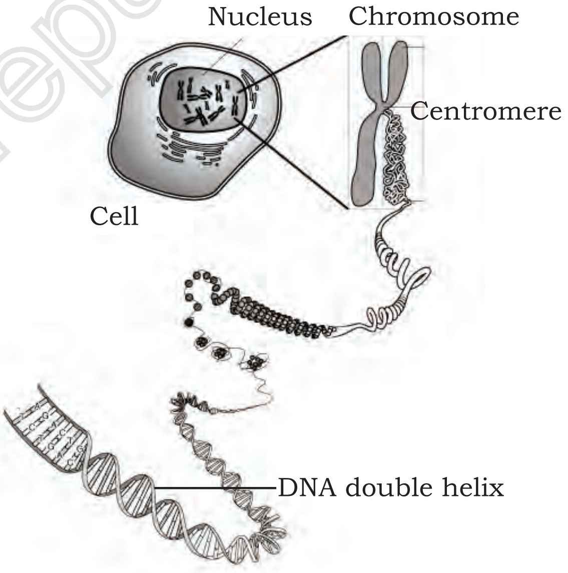


Fig 21.4
Structure of chromosome

Activity 21.6

Observe a permanent slide showing the stages of cell division and try to identify the chromosomes with the help of your teacher.

The chromosome is found to be made up of two main substances namely, proteins and nucleic acids. Each chromosome consists of two parallel strands called **Chromatids** which are held together by **centromere**. The ultrastructure of chromosome shows that protein molecules are surrounded by a highly coild thread of DNA. The DNA molecule consists of thousands of hereditary units called genes. These genes control every type of character or trait in an individual. To understand the structure of a gene we need to know about the structure and function of DNA.

Structure of DNA

Deoxyribose Nucleic Acid is a macromolecule with high molecular weight. It is the genetic material which carries genetic information from one generation to the other. DNA is present in almost all the organisms except a few plant viruses.

James Watson (USA) and **Francis Crick** (England) explained the structure of DNA molecule in 1953 for which they were awarded with Nobel Prize in 1962. They proposed the **double helix model** of DNA to give a most satisfactory explanation on its structure. It is also called **Watson - Crick Model** of DNA.

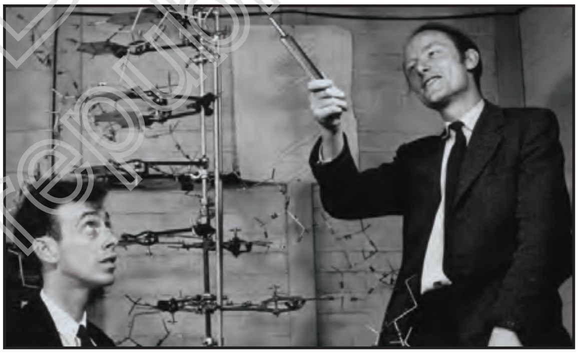


Fig. 21.5 Watson - Crick with their model of DNA

The structure of DNA molecule resembles a spirally twisted ladder. It is called **double helix**. The molecule of DNA has a pair of polynucleotide chains running antiparallel to each other. They are intertwined and each chain is helically coiled around the other. Each polynucleotide chain has a series of nucleotide units. Each nucleotide unit consists of three components namely, (1) Deoxyribose sugar, (2) Phosphate and (3) Nitrogenous base.

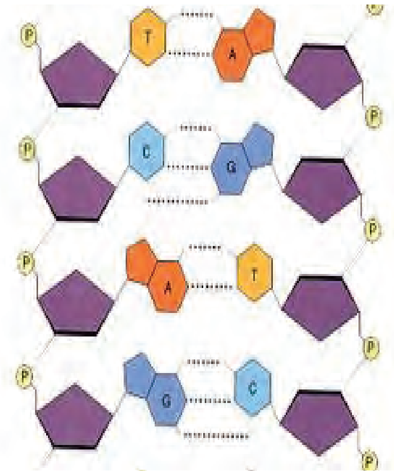


Fig 21.6 Nucleotide units with base pairing

The deoxyribose sugar is a **pentose sugar ($C_5H_{10}O_5$)**. Each strand of the ladder is made up of deoxyribose sugar and phosphate arranged alternatively. The nitrogen bases connect the two opposite strands like the rungs of a ladder. There are two types of nitrogenous bases namely **purines** and **pyrimidines**. There are two types of purine bases namely **Adenine (A)** and **Guanine (G)** and two types of Pyrimidine bases namely **Cytosine (C)** and **Thymine (T)**. A purine base on one polynucleotide chain always pairs with a pyrimidine base on the other. Adenine pairs with Thymine and Guanine pairs with Cytosine (A - T and G - C). This is called '**complimentary base pairing**'. Hence the two strands of a DNA molecule are always **complimentary** to each other but are **not identical**.

Think

During the cell division, how do the daughter cells get the same genetic information from parent cell? How is the genetic material of mother cell equally distributed between the daughter cells?

Replication of DNA

The daughter cells produced by cell division must receive the same genetic materials in same quantity so as to resemble the parent cell. For this reason the amount of genetic materials present in the mother cell must get doubled. When does and how does it happen?

During the interphase before the cell divides, DNA found in every chromosome replicates to ensure equal distribution of the genetic material to the future daughter cells. This process is called **DNA replication.** It is a very important event in the process of heredity.

The process of replication begins with the breaking of hydrogen bonds between the nitrogenous bases of complimentary nucleotide strands. The two strands of DNA helix get unwound to form a fork like structure. The two open strands serve as templates for the assembly

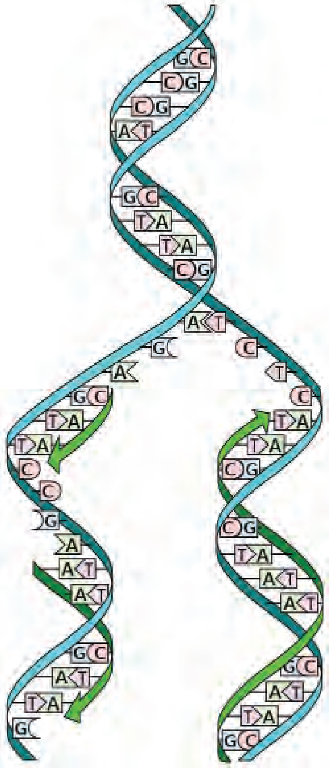


Fig 21.7
Replication of DNA

of new but complimentary nucleotides to form the daughter strands. The assembly of nucleotides on the parent DNA template is brought about by some enzymes. The assembly of new bases against the exposed bases of parent DNA strands takes place in a complimentary mode. This process continues till the two daughter DNA strands are formed.

Significance of DNA

- DNA has the coded information for controlling all the metabolic activities of the cell both directly and indirectly.
- By its special property of self replication, it ensures the equal distribution of similar genetic material to offsprings and thus responsible for heredity.
- DNA synthesises RNA which codes for the synthesis of specific proteins. So DNA indirectly helps in protein synthesis.
- DNA sometimes undergoes mutation and recombination which bring about variations in the characters of the offspring.

Know this

Mutation : *Any change in the structure or composition of genetic materials such as gene or chromosome is called mutation. It can be gene mutation or chromosome mutation. Gene mutation can occur naturally or it can also be induced. This is due to change in the base sequence of DNA. This may cause variation in offsprings.*

Let us suppose you want to send the following message to your friend

PLEASE SAY WHERE YOU ARE. *By oversight, you may send a message like this* **PLEASE STAY WHERE YOU ARE**. *In this statement only one letter 'T' was added by mistake, and the meaning of the whole message is changed.*

Even in the case of gene, if there is a change in the nitrogenous base, either by way of addition, deletion or change in position, there will be a change in the protein that is synthesized, its nature and function.

Think

Why are variations important?

What is the significance of DNA in organic evolution?

Is there any role of DNA in the formation of new species ? discuss.

Gene - the basis of Heredity : You all know that the parental characters or traits are inherited by children through genes. Each character or trait is controlled by hereditary units, which were called by Mendel as **factors**. It was **Johnson** who coined the term **Gene**.

Proteins are chains of amino acids. There are about 20 different types of amino acids. The sequence of these amino acids is a chain that determines what kind of protein it is. For example, a sequence of amino acids in keratin is different from that in Hemoglobin.

The cells produce thousands of different proteins by arranging amino acids in a particular order. The instruction for doing this comes from DNA.

A part of DNA which gives instructions for making a given kind of protein is called a **gene**.

DNA Technology

We have now learnt about heredity, variation and causes for the same. What is the significance of knowing this? This knowledge has led us to study the possibilities of many genetically related physical and physiological problems; improving the quality of plants and animals and even to obtain materials from plant & animals species for the human benefits. We have been seeing wide application of basic principles of heredity or genetics in many sectors of human life like agriculture, health, food management, conservation of environment etc.

Think

People who are suffering from diabetes mellitus are administered with Insulin. How is this Insulin synthesised in laboratory?

Earlier Insulin was extracted from the pancreas of pigs. Now synthesis of Insulin in the laboratory is done by using bacteria with the application of Biotechnology.

The application of technological procedures on organisms or their processes or their products to obtain new substances for human welfare is called **Biotechnology**. This is developed by the combination of cytology or cell and molecular biology, microbiology, genetics, biochemistry with the modern technology. In this modern world, application of biotechnology finds no limits. We see it right from a traditional practice of curdling the milk upto the synthesis of antibiotics and even creating a clone.

Activity 21.7

Make a list of some known examples of application of biotechnology in modern life.

DNA has been the vital material in all the biotechnological processes that are conducted in many fields of production and services. Some of the most usual and very significant applications of Biotechnology are as follows :

Genetic Engineering

It is the technique of inducing desirable changes in the genetic material such as DNA of an organism. This involves **recombinant DNA technology** by which genes are manipulated in the laboratory. It is possible now with this technique to separate the desirable or useful gene from a cell and introduce it into another cell where it is made to express.

DNA fingerprint Technology

In this modern world, as there is advancement in the field of biotechnology, we see a wider application of it in forensic sciences. You have seen or heard about legal disputes related to identification of dead persons, possibility of their genetic relationship with the claiming persons, identification of genetic relationship between parents and children etc. Many legal disputes related to genetic relationships have been successfully solved using DNA finger print.

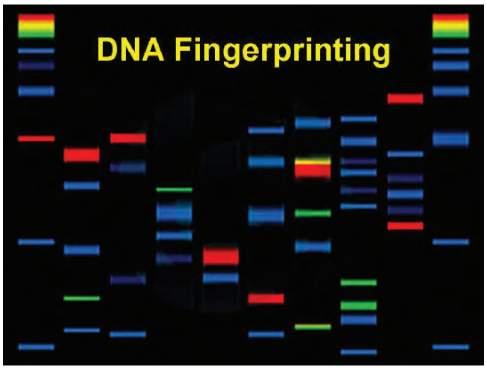


Fig. 21.8

DNA Finger print

This technique involves breaking down the DNA of an individual into short segments using specific enzymes, then separating the same using a process called **gel electrophoresis**. The fragments get separated on the basis of their size and net electrical charge. Shorter segments move fast when compared to larger segments and get arranged to form a series of bands in the form of fingerprint with a unique pattern. This is called DNA fingerprint. This characteristic pattern of bands is unique to each individual.

Cloning

It is now a rapidly developing application of biotechnology by which genetically similar molecules, cells, tissues or organisms from a common precursor are developed in-vitro laboratory condition.

Fig 21.9 Wilmut with his first cloned sheep Dolly

Know this

In 1997, the first clone of an adult sheep called ***Dolly*** *was developed by* ***Wilmut****.*

Applications of Biotechnology

- Large scale synthesis of life saving drugs like antibiotics, vaccines, artificial hormones etc.
- Improvement of plant and animal breeds, pest and pathogen control in agriculture.
- Synthesis of acceptable additives (preservatives, colouring agents, artificial flavours etc.) in food processing and management industries.
- Synthesis of biocatalysts and biopolymers.
- Pollution control : Sewage treatment or water recycling.
- By recombinant DNA technology it is possible to transfer nitrogen fixing gene from bacteria into plants which enable them to meet their nitrogen requirement.

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Activity 21.8

You can collect more information on the application of biotechnology in different sectors of the modern world and add to the list.

Limitations of Biotechnology

Biotechnology has played a very important role in improving the life quality of man in modern world through its limitless application in various fields. Do you think it has any limitations?

We have developed new varieties of plants through genetic engineering and tissue culture. This also has resulted in seed sterility which would cause severe threat to the conservation of plant species.

Genetically modified foods have started threatening the human and animal health. It is considered to be against nature and would upset the delicate balance of the nature.

Cloning would pose very serious social, ethical, moral and cultural problems. There are all possibilities of using this technique for illegal purposes and destructive activities.

Exercise

I. Answer the following questions

1. What is heredity?
2. Make a list of any four observable traits in pea plants with their contrasting forms of characters.
3. What is Monohybrid cross? What is its ratio? Show with the help of a checker board.
4. What were the four different varieties of pea plants obtained by Mendel in his dihybrid cross experiment? Show their ratio with the help of a checker board.
5. State the principle of dominance with an illustration.

6. State the laws of segregation and independent assortment.

7. What is incomplete dominance? Give an illustration.

8. What is complementary base pairing?

9. What is DNA replication? What is its significance?

10. What is recombinant DNA technology? What is its importance?

11. What is cloning?

II. Give reasons for the following

1. Hereditary variations are very important.

2. The two polynucleotide chains of DNA are not parallel but complimentary.

3. Though biotechnology is a boon to mankind, it may cause serious threat in future.

III. Differentiate between the following

1. Cross pollination - Self pollination
2. Phenotype - Genotype
3. Monohybrid cross - Dihybrid cross
4. Homozygous - heterozygous

CHAPTER 22

IONIC CONDUCTION

After studying this chapter you

- define the meaning of electrolytic conductors.
- distinguish between metallic conductors and electrolytic conductors
- define electrolytes.
- distinguish between different types of electrolytes.
- distinguish between electrolytes and Non electrolytes.
- state the Faraday's Laws of electrolysis.
- make a list of the applications of electrolysis and its importance.

In your previous class, you have studied various effects of electric current. Now let us study about chemical effect of Electric Current.

Electrolytic conductors

There are two types of electrical conduction, in the case of metals and alloys, electric current is due to flow of delocalised electrons and this is known as electronic conduction. This is a physical change as there is no change in the property of conductor.

There is another type of conduction in which cations and anions participate in the flow of electric, in presence of live electrodes in the case of molten state and aqueous solutions of salts. This is known as electrolytic conduction. This is a chemical change.

Let us know more about electrolytic conduction, by doing a simple activity.

Activity 22.1

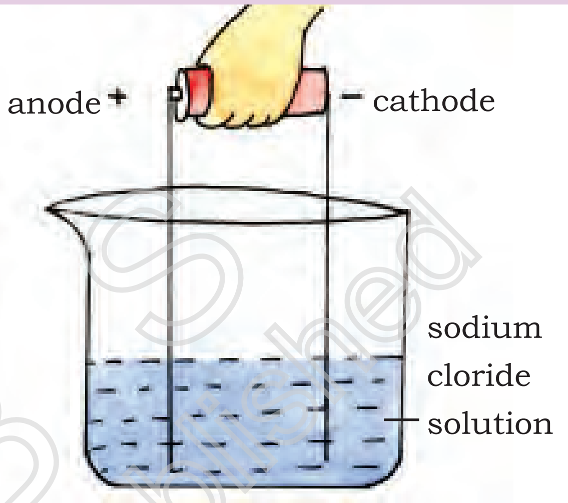

fig. 22.1 Electrolytic cell (volta meter)

Take an aqueous solution of table salt (Sodium Chloride) in a small glass vessel with a wide mouth or a plastic disposal cup. To this solution, add a little Turmeric powder (Haldi). The solution turns yellow. Project the terminals of a dry cell (1.5 V) by fixing two metallic stove pins as shown in the figure. Before immersing these stove pins in the solution, ensure that Turmeric particles are spread throughout the vessel. When these stove pins are immersed in the solution, you will see some gas bubbles evolving at the terminals. Also you will find that turmeric particles below the stove pin connected to the negative terminals ***turn red, since the medium alkaline****.*

(Turmeric powder remains yellow in acidic or neutral solution)

From this activity, we can note that, when direct current is passed through certain aqueous solutions, chemical reaction occurs. Such solutions are called **Electrolytic Solutions**. The chemical substances that conduct electricity in aqueous state (or molten state) are called **Electrolytes**.

Chemical substances in their molten state are aqueous state undergo electrolytic decomposition. This process is called electrolysis.

Conduction of electricity can be classified as follows.

Conductors of Electricity

Metallic Conductors | Electrolytic Conductors

Metals	Examples
Conduction takes place by the movement of electrons. Eg. Iron Aluminium, Copper, Mercury etc All alloys Eg. Brass, Bronze, Steel Graphite / Graphene (although there non metals behaves like a metallic conductor.)	Conduction takes place by the movement of ions in their molten state or aqueous solution. Eg. Sodium chloride, Calcium chloride, lead bromide. etc. **Aqueous solutions** of Sodium Sulphate, Copper Sulphate. Eg. Bases-Sodium Hydroxide Potassium Hydroxide etc. Aqueous solutions of acids (Hydrochloric acid, Sulphuric acid.)

Concentrated acid need not be strong and Dilute acid need not be weak why ?

Squeeze a lemon, to get few drops of juice. It contains concentrated acid. But does not cause burning sensation. It is weak but concentrated acid. To make Sharbat we dilute it with water. Concentration of an acid depends on number of acid molecules present per unit valume of it. While strength of an acid depends on the extent of ionisation.

Comparison between Metallic and Electrolytic Conduction

Metallic Conduction	Electrolytic Conduction
1. Physical change	Chemical change
2. Only Electrons conduct Electricity	positive as well as negative ions Conduct electricity
3. All metals and metallic alloys show metallic conduction.	Ionic compounds show electrolytic conduction in aqueous solution.

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Think

Between Metallic Conduction and electrolytic Conduction which is more efficient and why?

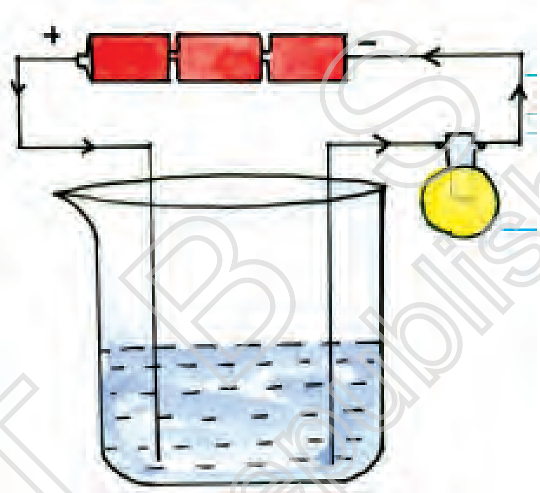


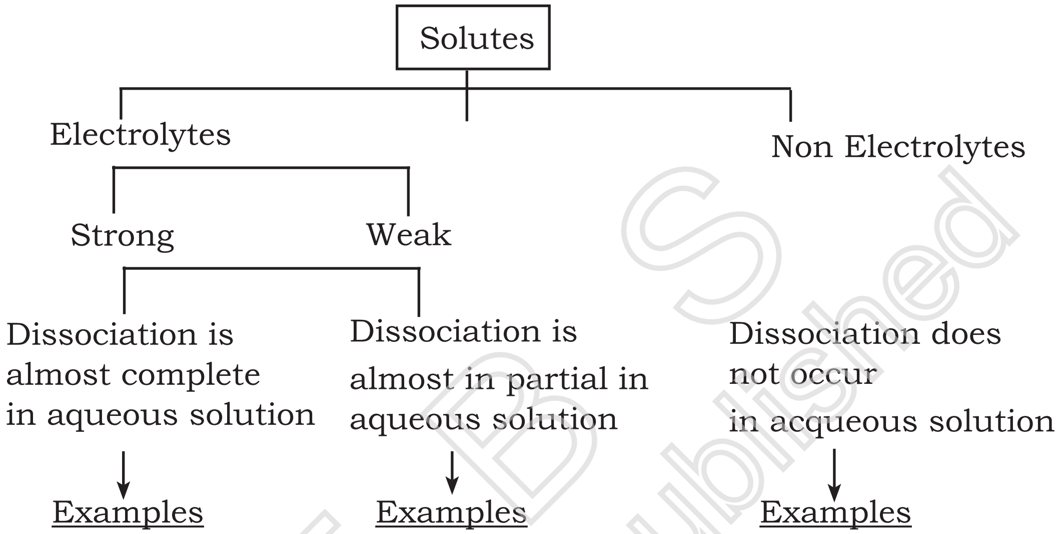
Fig. 22.2 Electrolytic cell

A simple Electric Circuit is set up as shown in the figure. The two stove pins acts as electrodes

Experiment	**Observation**
1) When electrodes are dipped in queous solution of sodium chloride.	bulb glows brightly
2) When electrodes are dipped in vinegar solution.	bulb glows faintly
3) When electrodes are dipped in sugar solution.	bulb does not glow

From the above experiments we can conclude that electrical conductivity varies with respect to aqueous solution of different electrolytes. Based on this solutes are classified as follows.

Classification of Solutes



Solutes

Electrolytes

Non Electrolytes

Strong

Weak

Dissociation is almost complete in aqueous solution

Dissociation is almost in partial in aqueous solution

Dissociation does not occur in acqueous solution

Examples

a) Ionic compounds sodium chloride Copper sulphate

b) Covalent compounds

Strong acids
Hydrochloric acid

Nitric acid,
Sulphuric acid

Examples

Weak acids

Carbonic acid

Phosphoric acid
Organic acids like
Acetic acid, Formic acid

Examples

Sugar solution
Distilled water

Arrhenius Theory of Dissociation

In 1887, Arrhenius proposed the theory of Electrolytic dissociation. According to this theory, an electrolyte in aqueous solution breaks into ions. (Charged group of atom) and freely move about in the bulk of the solution.

When an electric field is applied to an electrolyte, negatively charged particles move towards anode and get discharged. These are called **anions.** Similarly the positively charged particles move towards cathode and get discharged. These are called **cations.**

NOTE

Ion means wanderers. Ions are static in solids But they move throughout the bulk of solution and hence name ion is introduced.

What is an ION?

Electrolytes contain charged species / group of atoms. These charged group of atoms are known as Ions. They get separated in aqueous solutions.

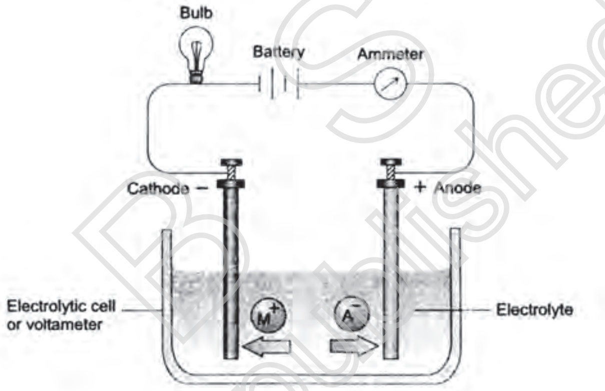
At Anode :

$Cl^- \xrightarrow{-e^-} Cl$

$Cl + Cl \rightarrow Cl$

At Cathode

$Cu^{2+} \xrightarrow{+2e^-} C$



(CuCl$_2$ Solution)

Fig. 22.3 Electrolysis

From the above diagram, it is clear that during electrolysis metal atoms deposited. (If hydrogen atoms are deposited they combine to form hydrogen molecules).

Similarly gaseous elements like oxygen, chlorine or bromine are deposited at anode as molecules of Oxygen, Chlorine or Bromine respectively.

Faraday conducted a number of experiments on Electrolysis and finally generalised two laws of Electrolysis.

Faraday's Laws of Electrolysis

First Law : The mass of substance deposited or collected at either electrodes during electrolysis is proportional to the product current and to the time.

If 'm' is the mass of substance deposited or collected at the electrode then according to first law of electrolysis,

Let mass deposited be m in kilograms.

Let the charge passed be **Q** in coulombs

Therefore $\mathbf{m \propto It}$

$\mathbf{m \propto Q}$ ....(1)

$\mathbf{m = ZQ}$

because $\mathbf{I = \frac{Q}{t}}$

Current $= \frac{\textbf{Charge flow}}{\textbf{time}}$

$\therefore \mathbf{Q = It}$

Where Z is proportionality constant, which is also known as Electro Chemical Equivalent (E.C.E).

$$\therefore \quad \mathbf{Z = \frac{m}{Q}}$$

$$\mathbf{Z = m}\ \textbf{(When } \mathbf{Q = 1}\ \textbf{coulomb} \text{ ....(2)}$$

Z is the mass of metal deposited when unit quantity of charge is passed or when unit current is passed in unit time.

Faraday's II Law of Electrolysis

The masses of different substances liberated at different electrodes by the same quantity of electricity are proportional to their chemical equivalents.

Second law relates between the mass deposited and chemical equivalent mass of the metal.

Let mass deposited be **m**

Let the chemical equivalent of substance be **E**

$$\mathbf{m \propto E}$$

$$\mathbf{m = KE} \text{ ....(3)}$$

There fore mass deposited at different electrodes will be

$$\mathbf{m_A = KE_A} \text{ ....(4)}$$

$$\mathbf{m_B = KE_B} \text{ ....(5)}$$

from the second law of electrolysis

$$\mathbf{\frac{m_A}{m_B} = \frac{E_A}{E_B}} \quad \text{(at constant } \mathbf{Q}\text{) ....(6)}$$

from first law, $$\frac{m_A}{m_B} = \frac{Z_A}{Z_B} \quad \text{(at constant } \mathbf{Q}\text{)}$$

$$\therefore \quad \frac{Z_A}{Z_B} = \frac{E_A}{E_B} \quad \text{........(7)}$$

Therefore $\mathbf{E} \propto \mathbf{Z}$ **or** $\mathbf{E} = \mathbf{FZ}$ ....(8) (**F** is Faraday's constant)

Faraday's constant is the quantity of charge required to liberate one gram equivalent of the substance.

It is denoted by **F**. It's value is approximately 96,500 coulombs / mole.

Hence $\mathbf{F} = \frac{\mathbf{E}}{\mathbf{Z}}$ (i.e $\mathbf{F} = \frac{\text{Chemical Equivalent } (\mathbf{CE})}{\text{Electrochemical equivalent } (\mathbf{ECE})}$)

Note : Chemical equivalent (**CE**) $= \frac{\text{Atomic Mass of a substance}}{\text{Valency}}$

Chemical equivalent is denoted by the letter **E.**

Faraday also referes the charge of Avagadro number of electrons.

Application of Electrolysis

1) Electroplating

This is a common application of Electrolysis The aim of Electroplating is to give the articles made of one metal a coating of another metal either to improve the appearance or to protect it against rusting and tarnishing.

The method is to set up a conducting cell with the article to be plated as cathode, a piece of plating metal as anode and a solution of salt of plating metal as the electrolyte, when a suitable current is passed through such a voltameter, the thin layer of metal is deposited on the article serving as cathode. In this way table forks, spoons and ornaments that are made of inferior metal can be coated with silver or gold to improve their appearance. It also prevents the corrosion of baser metals.

Schematic diagram of Electro Plating

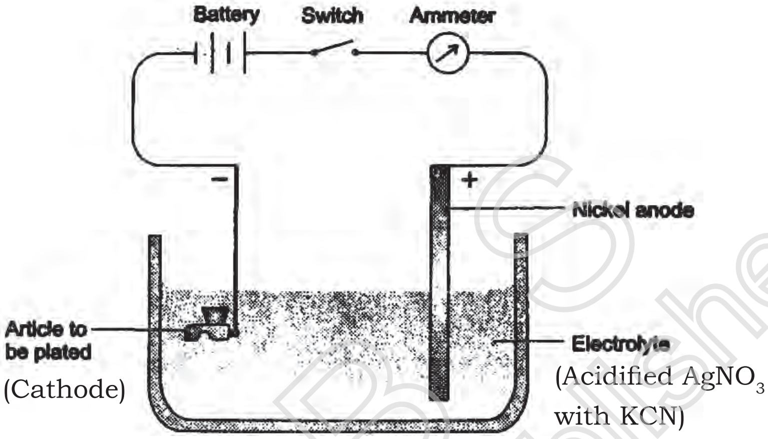


Fig. 22.4 Electroplating a Brass article with Silver

Electrolysis is used to purify metals from their impure samples. (Remember electrolytic refining of copper that you studied in the unit metals.)

> ***NOTE***
> Only less reactive metal can be deposited over more reactive

2) Electrotyping

Earlier it is used in printing of books, today it replaced by scanning.

3) Purification of metal : The impure electrolyte is electrolysed in the manner described above and pure metal gets deposited.

4) Decomposition of salts

Potassium and sodium metals are produced by Electrolysis of molten sodium and potassium compounds with iron electrodes.

5) Electro Polishing

Electro Polishing is a reverse of Electro plating. If an article rough stain less steel spoon is to be electro polished, then the steel spoon is taken as anode in the electrolytic bath with copper or lead anode and a suitable electrolyte. The metal is removed from the anode by the action of current. The elevated rough anode portion is removed which dissolves in the electrolyte. This results in electropolishing of anodes.

Eg: Sandwiched cookers are manufactured by the electro polishing method.

6) Manufacturing of certain chemicals like caustic soda

Problems

1) What mass of copper is deposited at the cathode in the copper voltameter by the passage of 2 ampers of current for 30 minutes.?

(E.C.E. of copper = 0.0003 g / coulomb)

Solution : $Z = 0.0003$ g/coulomb

$I = 2$ ampere

$t = 30 \times 60$ seconds, $m = ?$

$$m = ZIt$$

$$m = 0.0003 \times 1800 \times 2$$

$$= 0.0003 \times 3600$$

$$= 1.08 \text{ g}$$

$$m = 1.08 \times 10^{-3} \text{ Kg}$$

2) How many amperes of current is required to deposit 5g of gold on cathode is one hour ? If the E.C.E. of the gold is equal to 0.000681 g/ coulomb

Solution : $Z = 0.000681$ gm / coulomb

$I = ?$

$t = 60 \times 60 = 3\,600$ seconds

$m = 5$g

$$m = ZIt$$

$$\therefore I = \frac{m}{Zt}$$

$$I = \frac{5}{0.000681 \times 3600} = 2.04\text{A}$$

Exercise

I. Answer the following

1. Write any two examples for metallic conductors.
2. What is an electrolyte?
3. When electrodes are dipped in aqueous sodium chloride solution the bulb glows brightly. Why?

4. Identify the strong electrolyte in the following

   1) Acid diluted water (Acidified water) 2) Dilute acetic acid

   3) Sugar solution in water 4) Distilled water

5. What is electrolysis?

6. Name the cation in common salt solution.

7. Distinguish between cation and anion?

II. Four alternatives are given to each of the following incomplete statement / question. Choose the right answer

1. E.C.E. implies

   a. electro correlation equivalent b. electro chemical equivalent

   c. chemical equivalent d. electrochemical constant

2. Substances which conduct electricity in liquid or molten state are called

   a. electrolytes b. non Electrolytes

   c. conductors d. insulators

3. In a solution if dissociation is complete then the solution is a

   a. weak electrolyte b. non electrolyte

   c. strong electrolyte d. neutral electrolyte

4. The method of coating one metal layer on another is called

   a. electrotyping b. electro printing

   c. electro plating d. electro polishing

5. The article to be electroplated is taken as

   a. anode in the voltameter

   b. cathods in the voltameter

   c. it is placed in between anode and cathode of the voltamter

   d. as an electrolyte

6. The theory of dissociation was formulated by

   a. Arrhenius b. C. V. Raman

   c. Einstein d. Newton

7. Chemical equivalent of a substance is given by

   a. atomic mass × valency b. atomic mass + valency

   c. atomic mass ÷ valency d. atomic mass - valency

III. Answer the following questions

1. Define electrolysis.
2. Draw a neat labelled diagram voltameter.
3. Name the three types of electrolytes. Give an example for each.
4. Explain Arrehinius theory of dissociation.
5. E.C.E. of gold is 0.000681 2. What do you mean this?
6. State Faraday's laws of electrolysis.

IV. Match the following

A	B
1. Non electrolyte	a) Molten NaCl
2. Weak electrolyte	b) Distilled water
3. Strong electrolyte	c) Acetic acid
	d) Iron

V. Problems

1. How much time is required to deposit 1.10 gm of copper by passing 0.5 ampere of current. If E. C. E. of copper is 0.00033 gm/coulomb (answer 111.11 mins or 6666.66 seconds.)
2. To deposit 0.54 gm copper on cathode in a copper voltameter how much quantity of electric charges are required (If E. C. E. of copper 0.00033 gm/answer 1636.3 couloumb).
3. Silver voltameter and copper voltameter are connected in series. The amount of silver and copper deposited are 0.31 gm and 0.091 gm respectively. If the E.C.E. of copper is 0.00033 gm/coulomb. Calculate the E.C.E. of silver.

CHAPTER 23

THE STORY OF HUMANS

After studying this chapter you

- identify the relationship between humans and other primates.
- analyse the stages of human evolution.
- appreciate the biological changes which have occured in human evolution.
- understand the characteristics of each stage.
- differentiate the human races.

You are now familiar with the idea that organic evolution is responsible for the great diversity we are observing on planet Earth. You have also studied that it was **Charles Darwin** who gave the most accepted explanation for describing the mechanism of organic evolution, in the form of his **theory of natural selection**, proposed in 1859. Apart from this, it was Charles Darwin who suggested that human beings evolved from monkeys. Darwin published a book in 1871, called **The Descent of Man**, in which he noticed the similarities between man and apes .He even suggested that man, apes and monkeys have a **common ancestor.**

Long before Darwin's period, taxonomists-scientists involved in classification of living organisms- had placed human beings in the genus *Homo*, under the family **Hominidae**, in the order **Primates**, among mammals. This order included humans, apes and monkeys. Our closest living relatives are the gorillas and chimpanzees.

What characteristics do we share with other primates ?

- Primates have a distinct **face** in place of a snout observed in other mammals.
- Most of the skull is posterior to the eyes.
- Eyes directed forwards, enabling binocular vision.
- Free movement of the digits, especially the thumb which can oppose other digits.
- Claws modified into nails.

- Enlarged brain, especially the cerebral hemispheres.
- Only two mammary glands to nourish the young ones.
- Typically and generally only one offspring in each pregnancy.

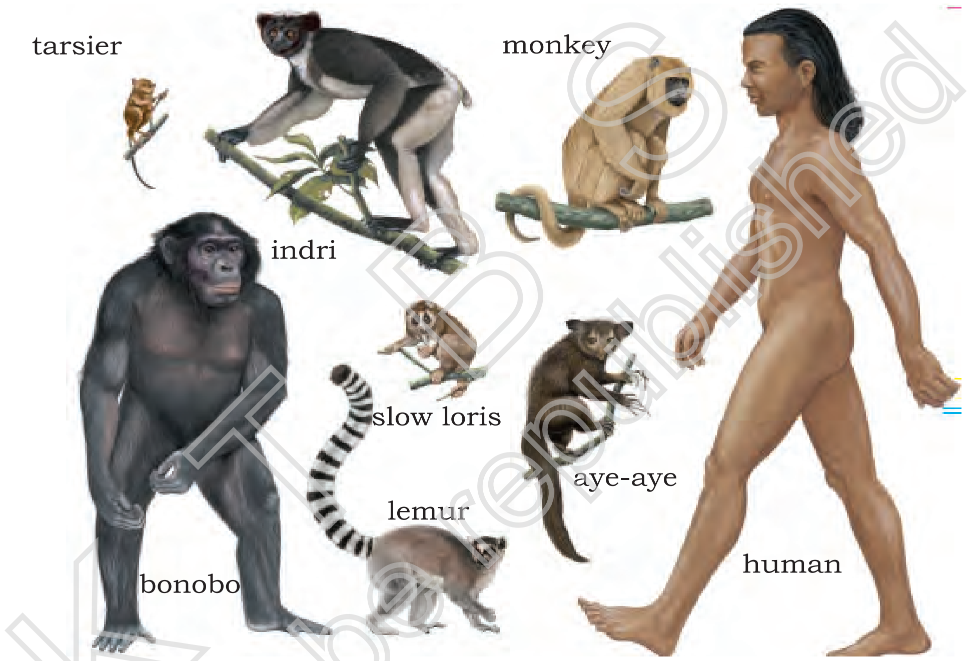


Fig. 23.1 Common Examples of Primates

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The tracing of human ancestors was initially based only on comparative study of living examples of primates. As biologists continued this study, primates and man were found to resemble more and more. The resemblences were more striking with gorillas and chimpanzees. Such studies only indicated that humans must have shared a common ancestor long, long ago with other primates.

Know this

Recent studies have indicated that the blood pigment haemoglobin of man and gorilla differ only in one amino acid. The D N A of man and gorilla differ only by about two percent !

You are aware that the most reliable and direct evidence for evolution comes from the study of **fossils.** The information obtained from the comparative study of humans and existing primates suggests only **what might have happened**, in the course of human evolution. However, to know **what did really happen**, one has to look into the study of human fossils.

Activity 23.1

Collect information about excavation stages of Human evolution.

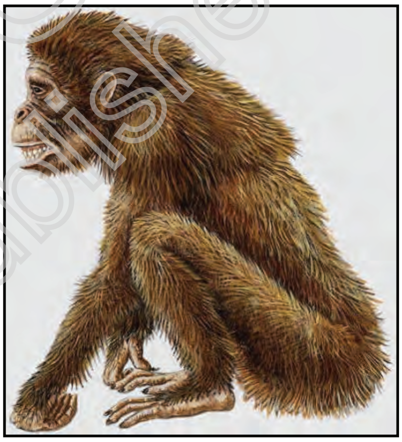

Fig. 23.2 Dryopithecus

About 15 million years ago, the ancestors of apes and humans probably evolved along separate lines. Both are said to have evolved from a semi erect terrestrial form of primates, which has been named as *Proconsul*. The ancestors of apes had strong muscular arms that were longer than the legs. These ancestral forms have been named as *Dryopithecus*. Fossils of these forms have been obtained in certain parts of Europe and China. Modern apes like oranguton, gorilla ,and human ancestors are presumed to have evolved from **Dryopithecus.**

In the course of further evolution, human types developed stronger and straighter legs with feet suited more for walking. The stereoscopic vision and acute hearing mechanisms were retained, while the prehensile nature of the big toe was gradually lost. They started using their grasping hands for various purposes. Their upright posture was the result of evolutionary changes in the pelvic girdle and associated muscles. The pelvic girdle changed into a broad basin-like structure to support the trunk. Another significant change in support of upright posture was seen in the skull. The hole in the skull through which brain comes out, got shifted to the lower surface. Cerebrum also showed considerable enlargement. These changes which appear to have occurred about14 to 15 million years ago, resulted in the arrival of an upright pre human. This form could focus its eyes on objects which it could hold. It was also able to manipulate objects with the help of flexible hands. This form of pre human has been called *Zinzanthropus.*

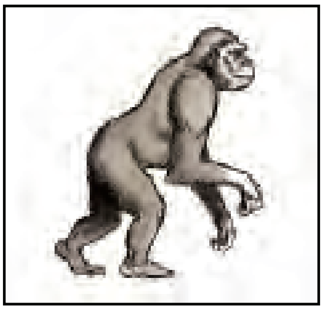

Fig. 23.3
Ramapithecus

About 13 to 14 million years ago, one of the descendent branches of pre human appeared in certain regions of India. This form has been called *Ramapithecus* (*Rama* signifying Indian origin and *pithecus* meaning ape). It is considered as the true ancestor of modern man. Only fossils of face and jaw bones have been recovered and studied. The remains of such a pre man have been obtained from the Siwalik range of our country. However, *Ramapithecus* is presumed to have had a wider distribution in both Australia and Africa.

Shortly after this period, shifts in the Earth's crust and severe changes in the climate, resulted in the conversion of large forests into grasslands. Such changes in the environment are presumed to have accelerated the evolution of our early ancestors.

About 5 million years ago, a descendent of *Ramapithecus* appeared in the drier regions of Easten and Southern Africa. It has been named as *Australopithecus* (meaning Southern apes). These forms are considered as **first humans**. They were relatively short, about four and a half feet in height. Forehead was low. The brain capacity was equal to the much taller modern gorilla .The cranial capacity was only about one-third of modern man. They walked erect, hunted in groups and perhaps used pebbles and bones as tools.

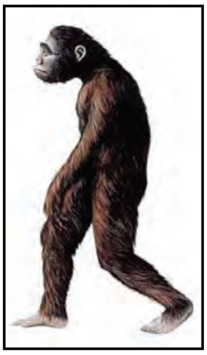

Fig 23.4
Australopithecus

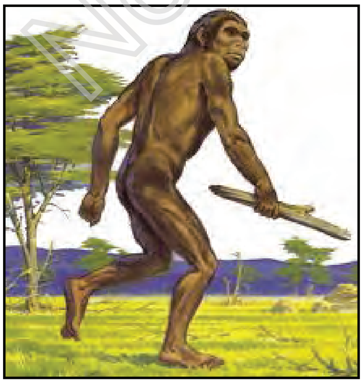

Fig. 23.5
Homo habilis

The Australopithecans gradually evolved into more distinctly human like forms that have been now placed in the genus **Homo**. The oldest known fossil skull of this genus dates back to about 2.5 million years. This form has been called *Homo habilis*. Cranial capacity was about 700 c.c. The limb bones resembled almost those of modern man. These forms of early humans are presumed to have used tools and weapons.

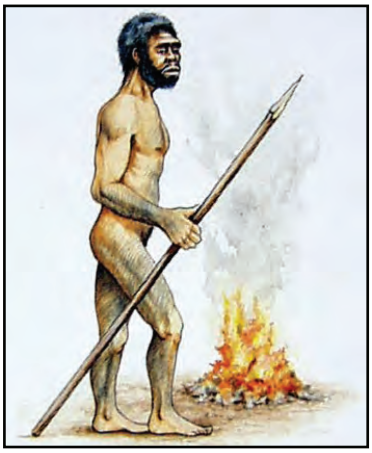

Fig. 23.6
Homo erectus

Homo habilis evolved into a more modern form of humans, called *Homo erectus*, about 1.5 million years ago. These individuals are said to have spread all over the world. Some forms of this group are described by the names-**Java man** and **Peking man**. Java man gets his name from a discovery made by a Dutch scientist, **Eugene Dubois** in 1891, of a fossil in a place called Java in Indonesia. Fossils of several individuals including a child, along with some crude stone tools have been discovered. In 1924, a group of Canadian biologists discovered the fossils of a similar group in Peking in China. This led to the discovery of Peking man. An array of chopping tools made of stones, were also found with these fossils. The occurrence of charcoal along with these fossils suggested that Peking man was using fire.

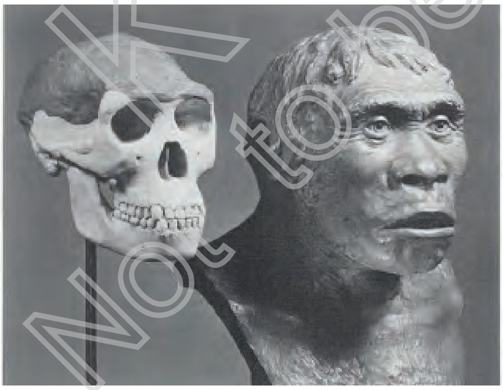

Fig. 23.7 Java man

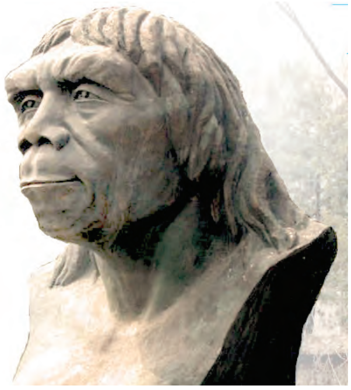

Fig. 23.8 Peking man

About 2,50,000 years ago, the species **Homo erectus** was replaced by *Homo sapiens*, the species to which the modern man belongs. Individuals of this species showed a larger brain capacity than their ancestral forms. Intellectual capacity was much higher. They had also developed language. They were using sophisticated tools and weapons.

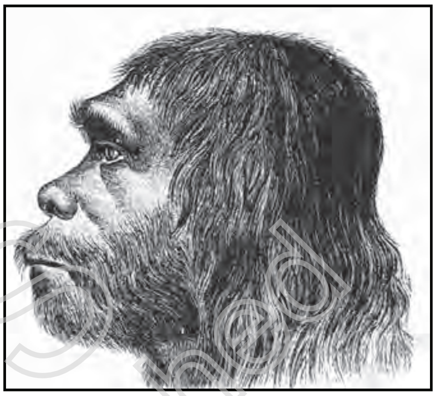
Fig. 23.9 Neanderthal man

The earliest form of *Homo sapiens* is commonly known by the name **Neanderthal man**. The first fossil of Neanderthal man was discovered in 1856, in the Neanderthal valley of Germany. Neanderthal man appeared in Eurasia and Northern Africa, a little before the last glacial advance. He was rather short, heavily built and exceedingly strong. Brow ridges were heavy. Fore head was sloping with small chin and protruding jaws. He was good in making tools. He is presumed to have developed speech.

The Neanderthal man is said to have disappeared about 50,000 years ago, during the last glaciation. There are various theories to explain the causes of his extinction. It is generally believed that Neanderthals were overpowered and replaced by men very similar to ourselves. Perhaps they were exterminated because of their inability to compete with a culturally more advanced group of men, armed with better tools and weapons.

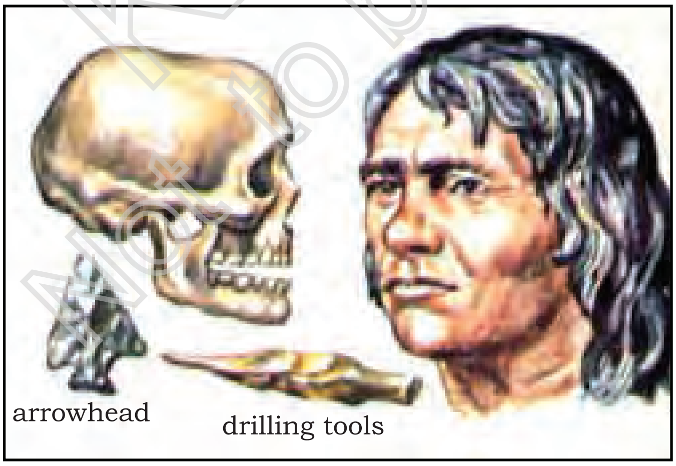

Fig. 23.10 Cro-Magnon man

The Neanderthals were replaced by a group of early men known as **Cro-Magnon men**. Their first fossil was discovered in a cave in a place called **Cro-Magnon**. The Cro-Magnon man is presumed to have lived about 30,000 years ago,around the end of ice age. He had a large stature. He was active and intelligent. The superb paintings made by these men in some caves in France and Spain indicate their associations with animals. They used finely chipped stone arrows and spear points. They carved tools and ornaments from ivory.

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Modern man is not very much different from Cro-Magnon man in terms of biological evolution. What sets them apart is only the cultural evolution. Culturally modern man is more advanced. He is capable of thinking, memorizing, speaking, reading and writing. He developed agriculture and started domesticating animals. He has also learnt to manipulate nature according to his needs. He has developed science and technology using his intelligence. He has emerged as the most dominant creature on this Planet Earth.

Human Races

You have observed that there are significant differences between human beings inhabiting different countries. You might have wondered as to how these different looking individuals are placed in the same species-**Homo sapiens**. There are many prominent variations that can be identified among different groups of humans. Colour of the skin, hair and eyes, shape of the nose, texture and distribution of body hairs and thickness of the lips are some such characteristics. Based on such differences, anthropologists- scientists who study humans-have classified humans into subdivisions called **stocks** or **races**. They are the result of a long history geographical isolation, dating back to about 25,000 years. Broadly the following five races have been identified.

- **Caucasoids** are generally characterized by light skin, blue or dark brown eyes and a high ridged nose with narrow nostrils. Hair is straight or wavy. They live in Europe, India and certain parts of America.
- **Mongoloids** are characterized by yellowish or reddish skin, fairly thick lip and wider nose. Hair is straight. They include the people of China, Japan, Mongolia and Malaysia along with Eskimos and American Indians.
- **Congoids** are characterised by black skin, thick lips and broad nose. Hair is woolly. They are also called negroids. They occur mostly in Central and South Africa.

- **Capoids** are characterized by black or brown skin. They are represented by bushmen of Africa.
- **Australoids** are characterized by brown skin, curly hair and deep eye sockets. They are the original inhabitants of Australia.

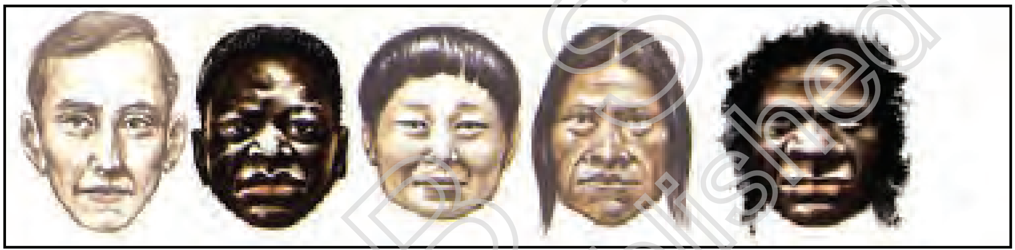

Fig. 23.11 Human races

The human races do not exhibit much differences genetically from one another. The races are able to breed among themselves, producing fertile offspring. These races are mainly social categories by which persons can be identified from each other.

Activity 23.2

Collect pictures of human beings from different countries. Try to identify the races to which they belong.

Exercise

I. Fill in the blanks with suitable words.

1. The group to which humans are classified under mammals, is called ______________.
2. The ancestral forms of apes and humans have been named as ______________.
3. The fossil remains of Ramapithecus have been identified from _____________ in India.

4. The earliest form of Homo sapiens is known as_____________.

5. The sub divisions of human species are called _____________.

II. Name the following

1. The condition caused by shifting of both the eyes forwards
2. The first form of pre human identified.
3. The first human forms discovered in Eastern and Southern Africa
4. The name given to the oldest known fossils of human like forms
5. The earliest form of Homo sapiens.

III. Answer the following questions

1. Make a list of the features exhibited by Ramapithecus
2. How was Australopithecus different from Ramapithecus?
3. Write a brief note on Java man and Peking man
4. Describe the main human races.

* * *

CHAPTER 24

SPACE SCIENCE

(A) STARS AND GALAXIES

After studying this chapter you

- describe the protostar stage of a star.
- state the conditions for a star to attain the steady state.
- give the reason for the enormous output of energy during steady state of a star.
- explain the process of a star to change from steady state to red giant stage.
- state what the supernova is.
- name the types of Galaxies.
- state the experimental evidence for proposing Big Bang Theory.

Astronomy is an ancient science. Day and night which repeat after regular intervals of time are said to have led to the measurement of time. Locating the directions is also one of the consequences of sky watch. many words in any language is based on astronomy observations. The word month is derived from moon. Names of days are synonymous with the names of planets/stars.

The roots of Astronomy reach back to pre-historic times when humans first noted the little points of light called stars. There are hundreds of billions of stars that shine in the universe, but a few thousands are identified by naked eyes. From then, these objects of light have fascinated humans and drawn them to explore the night sky.

A telescope can give the details of moon or planets but no details of stars as they are really far away from us. Many brightest stars are many light- years away from us. Because of their distance, all stars appear to be equally remote as on the celestial sphere. This chapter is about the life of stars, types of galaxies and birth of the universe. You might wonder to know that stars are born, they grow up, exist for many years and then they die!

Yes stars also have their life cycle just as we have. Their study has given us a fairly good idea of how stars form, live and die. We now know that the smallest of them quietly burn out at the end of their lives, while the most massive ones end in spectacular explosion.

Birth of stars

The process from the birth to the death of star is called stellar evolution. Interstellar space contains huge gaseous clouds. Mostly rarefied hydrogen exists in space. These gaseous clouds contract due to their mutual attraction. As the cloud contracts, there will be increase in density which in turn leads to increase in pressure. Gradually there will be aggregation of matter (mostly Hydrogen) with the spherical mass at the centre of the cloud. In this stage the only force acting is the gravitational pull towards the centre. The central portion alone accounts for 99% of the mass of the cloud. The sphere formed at the centre is called **protostar**. This is a forming star. It takes millions of years to form a star

Mutual attraction between the gaseous particles results in contraction of this huge ball of gas. The density at the centre increases as the matter in the Protostar is crunched together, with the rise in temperature and pressure. When the temperature reaches about 10 million Kelvin, some of the Hydrogen nuclei fuse to form Helium nuclei producing large quantity of heat, light and radiation. This energy liberated is radiated out. Thus a star is born. At this stage, there will be radiation pressure acting outwards, which tends to expand the star. But the inwards gravitational pull balances it. Thus a star reaches a **steady state**.

A star can remain in this state for several billions of years depending on its mass. In low-mass stars, hydrogen fusion occurs at a slower rate and the stars are dimmer and live longer. And in massive stars fusion occurs at furious rate, these stars are bright and have relatively short life. Sun has been in this stage for about five billions years.

What is a Red Giant?

A star on reaching the steady state, will start giving out steady output of energy. As the radiation pressure increases beyond the opposing gravitational pull, the star begins to swell. Consequently, the surface area will be more. As a result of this radiation loss and hence the temperature of the star decreases and hence it emits light which is low frequency radiation. And the star is said to be RED GIANT. All red stars are of this particular nature.

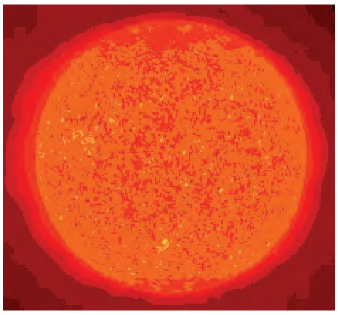

Fig 24.1 Red giant

All stars will have a common path up to red giant stage.

As the stars envelop expands, their core contracts, the temperature reaches 10^8 K, helium is converted into carbon in the core. When all the helium gets converted to carbon, the core cannot contract further. The only force that exists is the outward pull of radiation. Due to this, the outer envelope of Red Giant gets detached and thrown out into space. It forms a cloud called **Planetary Nebula**.

Know this

Sun on reaching red giant stage, will swallow up mercury and venus. the temperature on the earth rise to such an extent that the atmosphere is blown off and the oceans go dry!

White dwarf

After the Red Giant the future of the star depends on the mass of the star. The star after losing Planetary Nebula has the mass less than 1.4 times of mass of the sun. [1.4 times mass of the sun is known as Chandrasekhar's limit] The star collapses under the gravity. The increase in temperature and pressure prevents further collapse. Due to very high temperature, the star glows with white light of high frequency. It is called **White Dwarf.**

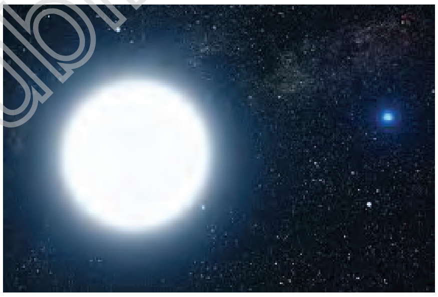

Fig. 24.2 White Dwarf

Know this

The matter in white dwarf is so compressed that a tea spoonful matter weighs hundreds of tons.

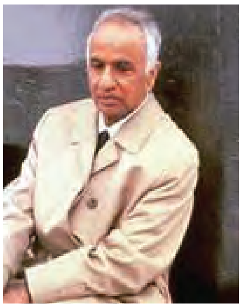

Fig. 24.3

Dr.Subramanian Chandrasekhar was born in October 19, 1910 in Lahore. He studied physics at Presidency College Chennai. In 1930 he became a research student of R.H Fowler at Cambridge University and earned his PhD in 1933. He developed the theory of White Dwarf and showed that the star of a mass is greater than 1.4 times that of Sun known as Chandrasekhar's limit had to end its life by collapsing into an object of enormous density such as a Black Hole. He shared the 1983 Nobel Prize in Physics with W.A Fowler for his studies of physical process of the importance to the structure and the evolution of stars.

What is the future of the stars (after red giant stage) if their mass is more than the solar mass?

Stars which are 5 times more massive than Sun evolve differently after Red Giant stage. Their evolutions have several stages of nuclear reactions ignited one after the other. The carbon nuclei produced during the fusion of helium forms carbon core. The carbon nuclei in the core fuse and liberate energy while synthesizing heavier elements like oxygen, magnesium and silicon. This fusion cycle repeats until the element Iron is formed. At this stage, the star explodes and the event is called **Supernova Explosion,** one of the most spectacular events.

fig. 24.4
Supernova Explosion

The remnant of supernova sometimes condenses to a core composed of tightly packed neutrons. This super dense remnant of supernova is called **Neutron Star.**

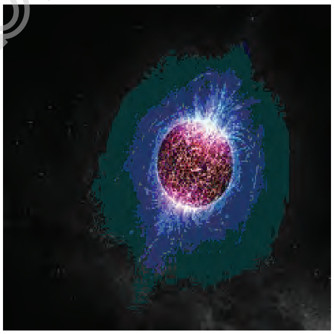

fig. 24.5 Neutron star

Fast spinning Neutron Star emits radiation in pulses and are called **Pulsars**. As the Pulsar spins, the beam of radiation it emits sweeps over the earth, which we detect as pulses.

Quasars

Quasars were first thought to be faint stars in our galaxy. In 1960 astronomers found that they emit radiowaves. Radio waves are observed coming from the galaxies but no star had been observed to emit radio waves. These objects were called "Quasi Stellar Sources" shortened as Quasars.

Black Holes

In the case of stars whose mass is 30 times as that of the Sun, the remnant of Supernova explosion has huge amount of matter compressed into a very small region of intense gravitational field and is called a **Black Hole**. Because Black Holes contain an enormous quantity of extremely dense matter, they have incredible gravitational force. This is a gigantic and dense Neutron star.

A black hole can be recognized by its properties like density and gravity. The properties like temperature, pressure or chemical properties cannot be determined. This is because its gravity is so high that even light cannot escape from it. No information in the form of light or radio waves comes out of it.

Imagine

If our sun collapses to a radius of 3 km, the sun would be invisible. It would become a black hole.

Colour of Stars

If you look up into the night sky, you will see the stars appear to be white at first glance. But if you look carefully you will notice that the colour of stars range from blue to red yellow and orange. What gives colour to a star?. In fact the colour of the star depends on its temperature.

The analysis of the lines of the spectrum of the stars helps us to identify the elements present in the stellar atmosphere. The intensity distribution of these elements decides the apparent color and hence the temperature of the stars. The surface temperature of the stars range from about 2000 K for reddish stars to about 50000 K for bluish white stars.

Temperature	colour	star - example
2000-3500 K	Red	Betelgeause
3500-5000 K	Orange yellow	Arcturus
5000-6000 K	Yellow	Sun
6000-10,000 K	Yellowish white	Sirius
10,000-50,000 K	Bluish white	Rigel

Activity 24.1

Observe the night sky, and identify the following stars. Also get to know their names from the experts.

1 Brightest star

2 Red Star

3 Stars which appear in different colours.

Galaxies

Galaxies are system of stars, gas and dust. The stars, gas and interstellar dust orbit around the centre of the galaxy. Galaxies are believed to be the breeding grounds of stars. Our own Star, the Sun is an ordinary star among 200 billion others in a galaxy known as **Milky Way or Akasha Ganga**.

Facts about our galaxy Milky way

- The diameter is about one lakh light year.
- As viewed from the edge it looks like a flat disc with a central bulge and the thickness tapers towards the edge.
- Its central thickness is about 6000 light year. Sun is located about halfway, that is 28,000 light years from the centre. It takes about 250 million years to go around the centre of our galaxy.

Astronomers believe that 10-15 billion years ago galaxies formed from huge clouds of gas pulled together by gravity.

There are different types of galaxies in the universe. They not only appear different but they have different evolutionary history. Three fundamental types of galaxies are elliptical, spiral and irregular galaxy.

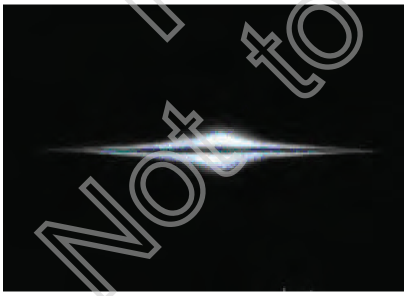

Fig. 24.6 Milky way when viewed from an edge

Elliptical galaxies

Elliptical galaxies are most common galaxies in the universe. Most of the stars in them are relatively dim and they are more difficult to see than other types of galaxies. They contain

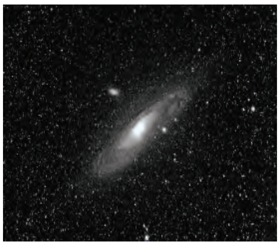

Fig. 24.7 Elliptical galaxy

trillions of stars or even more. The width of the elliptical galaxies is as much as 2 million light years.

Spiral galaxies

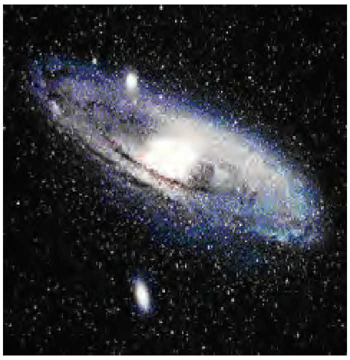

Fig. 24.8
Spiral Galaxy

Spiral galaxies are the most beautiful arrangement of stars in the universe. They are bright and have newly formed stars. These galaxies when viewed from one direction, they look like a flat disc with a central bulge and the thickness tapers off towards the edge.

When viewed from perpendicular direction they look like a spiral.

Our own Galaxy, Milky Way is a typical example of spiral galaxy. The diameter of the Milky Way is about one lakh light years, and its thickness is about 6000 light years.

Irregular galaxy

Irregular galaxies as the name itself suggest have no spiral arms or dense centers. They are normally small and faint and are difficult to detect.

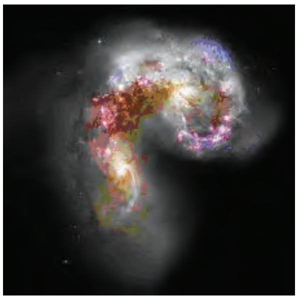

Fig. 24.9
Irregular galaxy

How did Universe begin?

Our Universe is so vast, beautiful and dynamic! Have you ever thought how all this began?

Based on the model of supernova explosion of stars that led to the formation of new stars, it is proposed that the universe might have begun with a start of explosion. This is known as **Big Bang theory**.

The concept of Big Bang came into light in 1930's when American Astronomer Edwin.P.Hubble (Hubble telescope is named after him) showed that the Universe is expanding. Further study revealed the fact that everything what we have in the universe was once concentrated in a very small, hot place called **Primordial Fire Ball.** Something triggered and the fire ball exploded with a bang. And the matter in it was thrown away with tremendous speed. From then everything in the universe is receding from each other.

The analogy of the dots on a balloon will help us to understand the concept of expanding. Any two dots on the balloon will move away from each other as the balloon bloats.

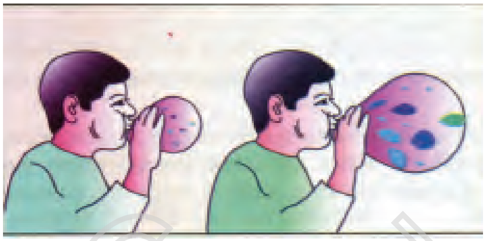

Fig. 24.10

Know this

Scientists from European organisation for nuclear research (CERN) working with the most expensive particle collider - Large Hadron collider believe that they have discovered an elementary particle called 'Higgs Boson'. It is named after Peter Higgs and Dr Bose a famous Indian scientist who first predicted them in 1964

Boson is often called 'God particle', because it is said to have caused big bang that created our universe millions of years ago. Boson is believed to be building block of universe and is what gives mass to matter.

Note: Get to know more about this from Internet

Edwin Hubble with his co-workers made a systematic study of the Red-Shift of various Galaxies. This study led to the discovery that Red Shift of Galaxy is proportional to the distance from us. Today we know this as Hubble's law-"**The velocity of recession of a celestial body is proportional to its distance from us**."

The universe was born in a violent expansion. Will it contract under its gravity? Is the universe finite or infinite?

The quest for the answer to these big questions is in cosmology!

Exercise

I. Four alternatives are given to each of the following incomplete statement / question. Choose the right answer

1. The raw material for the formation of protostar is

   a) coal b) helium c) hydrogen d) uranium

2. In which of the following stage is the Sun?
   - a) red Giant
   - b) white dwarf
   - c) protostar
   - d) steady state

3. The first element formed within few minutes after Supernova is
   - a) helium
   - b) hydrogen
   - c) nitrogen
   - d) oxygen

4. The heaviest element formed in the stellar evolution before supernova explosion is
   - a) calcium
   - b) silicon
   - c) neon
   - d) iron

5. The diameter of Milky Way is about
   - a) six lakh light year
   - b) two lakh light years
   - c) one lakh light year
   - d) ten Lakh light year

II Match the following

	A	B
1.	The Sun	a) Red
2.	The Sirius	b) Bluish white
3.	The Rigel	c) Orange yellow
		d) Yellowish white
		e) Yellow
		f) Green

III. Answer the following

1. How is a protostar formed?
2. When does a star attain Steady State?
3. Explain the evolution of a star whose mass is five times the mass of a star.
4. Explain the Big Bang theory.
5. State Hubble's law.

(B) ROCKETS AND ARTIFICIAL SATELLITES

After studying this chapter you

- get to know the historical importance of Rocket Technology.
- explain the principle of rockets.
- get to know the rocket launching technology.
- define orbital velocity and escape velocity.
- know the advantage of multistage rocket over a single stage rocket.
- feel proud of India's space programme including Chandrayaan.
- make a list of the uses of artificial satellites
- know more about the contribution of Indian to technology.

Rocket science is synonymous to intellectual complexity, because rocket science encompasses various branches of science and technology, along with environmental studies meteorology and so on. But the new research shows that the first rockets used by Chinese were simple arrows of flying fire. These arrows of flying fire have now transformed into a powerful rocket systems that can place satellites and humans into earth's orbit and enable us to explore space as well.

Launching the first artificial earth satellite was a major breakthrough in the development of science and technology. This was possible by the invention of modern rocket. Rockets are called launching vehicles as they carry the artificial satellite from the earth to space.

Know this

Fig .24.11
Konstantin Tsiolkovsky

Konstantin Tsiolkovsky a Russian rocket scientist along with his co-workers, German Hermann Oberth and American Robert H Goddard are considered to be the founding fathers of rocketry science.

Konstantin Tsiolkvsky worked on designs of rockets, multistage boosters, Space stations and so on.

Unlike aircraft which uses oxygen in the atmosphere, oxidizer which is necessary for burning of the fuel has to be carried in the rocket as it operates in the outer space. This mixture of oxidizer and fuel is called PROPELLANT.

Some Rocket propellants are,

1. Liquid Hydrogen and liquid Oxygen.
2. Kerosene and liquid Oxygen.
3. Hydrazine and Nitric Acid.
4. Synthetic rubber or Cellulose base compounds and liquid Oxygen.
5. Polybutadiene and Acrylic acid with oxidizer such as aluminum percolate.

Note

There is historic evidence to show that Tippu Sultan used rockets in wars.

Activity 24(B)-1

Blow a balloon and let it go. You will find it moving in the direction opposite to the direction in which air is ejected. This demonstrates the principle of rocket propulsion.

Principle of Rocket propulsion.

To understand the working of the rocket, first we have to understand the Newton's third law and the principle of conservation of momentum.

According to the principle of conservation of momentum the total momentum of the system is conserved when the net force acting on the system is zero.

Let us assume that a bullet of mass **m** is fired with velocity **v** from a riffle of mass **M**. Before firing both the bullet and the riffle are at rest. Therefore the total momentum is zero.

Total Momentum before firing =0.......... (1)

When the bullet is fired, the bullet leaves the nozzle of the riffle with a momentum **mv**, and the rifle recoils with the velocity **V**.

Total Momentum after firing= mv+MV.......(2)

As the total final momentum must be zero even after firing,

$$MV + mv = 0$$

$$MV = -mv$$

$$V = \frac{-mv}{M}$$ ….. This is an expression for the recoil velocity.

The rocket works on the same principle. During the firing of the rocket, the propellant burns and large amount of gas is pushed out at high velocity. The ejected gas pushes the rocket with a high velocity in the opposite direction and the rocket acquires an equal momentum.

So, when the fuel in the rocket burns, the exhaust gases escape through a nozzle towards the earth, in reaction to this the rocket moves vertically upwards.

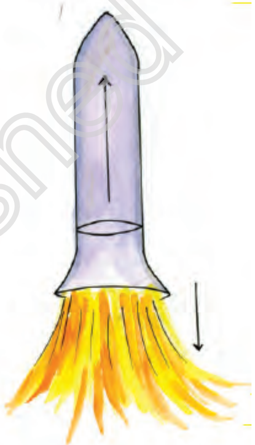

Figure 24.12

Working of Rocket System

The mass of the rocket (M) includes the mass of the propellants and the scientific instruments or the satellite in the rocket. The scientific instrument which is usually placed in the front region of the rocket is called PAYLOAD. The acceleration of the rocket is decided by the amount of fuel burnt and the Exhaust velocity (V_{ex}), The mass of the rocket (M) also plays a role. Larger the mass of the rocket lesser is the acceleration.

It can be shown that

(rate of fuel consumption x exhaust velocity) = (mass of the rocket x acceleration)

Here the product (mass x acceleration) is called **THRUST** on the rocket.

$$\text{Thrust} = RV_{ex} = Ma$$

Where R is the rate of fuel consumption.

Know this

The practical aspects that need to be considered when the rocket operates are

- As the rocket consumes fuel at every instant, its mass goes on decreasing.
- The acceleration due to gravity changes continuously as the rocket ascends.
- The atmosphere offers resistance in the lower strata of atmosphere.

In a single staged rocket, a chamber called engine is the place where the combustion takes place and the exhaust gas comes out of the nozzle. When a rocket is designed, the ratio of payload mass (m) to the fuel mass (M) called payload ratio is needed. Oxidizer and the fuel are stored in separate tanks. They are supplied to the engine in controlled quantities with the help of valves.

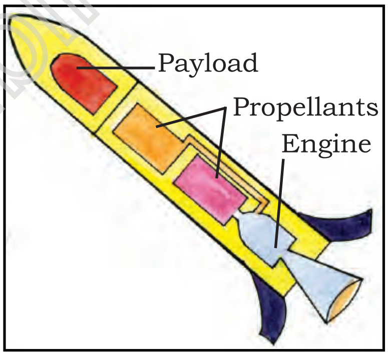

Figure (24.13) of a single staged rocket

Know this

The characteristic external shape of the rocket called streamlining of the rocket minimizes the friction of air. It also gives stability to the rocket when it moves in the earth's atmosphere

Orbital Velocity (v_o)

The rocket places the satellite in a circular orbit around the earth. The centripetal force for an artificial satellite executing circular motion around the earth is provided by the gravitational force of the earth. The velocity of the satellite along a circular path is called the orbital velocity(v_o).

Consider an artificial earth satellite of mass **m** going round in the circular orbit of Radius **R** with a velocity $\mathbf{v_o}$. If **h** is the height of the satellite above the earth surface, and' M' is the mass of the earth , the earth's gravitational force acting on the satellite is

$$\vec{F}_G \quad \frac{GMm}{(R+h)^2} \text{ ....(1)}$$

G - Gravitation Constant = 6.672 10^{-11} Nm^2 kg^{-2}

This force acts as centripetal force for the circular motion of the satellite in its orbit. The expression for the centripetal force is

$$\vec{F}_{cp} \quad \frac{Mv_0^2}{(R+h)} \text{ ....(2)}$$

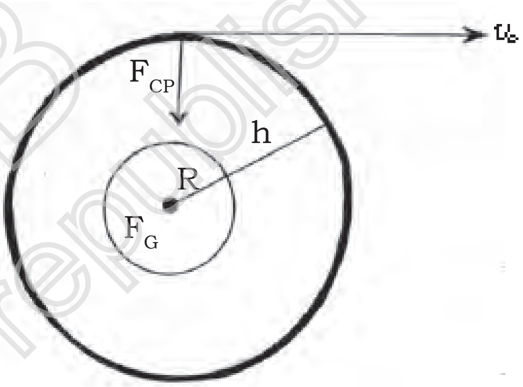

Figure (24.14)
Artificial satellite in earth orbit

From (1) and (2)

$$\frac{mv_0^2}{(R+h)} \quad \frac{GMm}{(R+h)^2}$$

$$V_0^2 \quad \frac{GM}{(R+h)}$$

$$V_0 \quad \sqrt{\frac{GM}{(R+h)}}$$

When 'h' is sufficiently small when compared to R, h can be neglected. Thus

$$V_0 - \sqrt{\frac{GM}{R}}$$

$$g - \frac{GM}{R^2} \text{ or } \frac{GM}{R} \quad Rg$$

$$V_0 \quad \sqrt{Rg}$$

Multistage Rockets

Artificial Satellites have to be placed at very great heights. A single rocket cannot push the satellite to such great height. Therefore multistage rockets are used for this purpose.

In a multistage rocket several rockets are joined together one on top of the other to provide the necessary power. By using such a rocket, the fuel consumption can be reduced.

The rocket on reaching a height of about 100 km gets rid of the first stage. The engine of the second stage begins to act. The mass of the rocket is reduced. The second stage takes the rocket to still greater heights and detaches itself. The third stage takes over and so on. This increases the efficiency of the rocket .

Escape Velocity (v_e)

The minimum velocity with which a body must be projected so that it escapes from the gravitational field of earth is called ESCAPE VELOCITY (v_e).

It can be shown that $v_e = \sqrt{2Rg}$ Where 'R' is the radius of the earth and 'g' is acceleration due to gravity.

From the above expression,we find that the escape velocity is independent of the mass of the body.

For earth $R = 6.37 \times 10^6$ m. $g = 9.8\ ms^{-2}$

When we substitute this in the equation $v_e = \sqrt{2Rg}$

$v_e = \sqrt{2 \times 6.37 \times 10^6 \times 9.8}$

$v_e = 11.2\ Kms^{-1}$

The orbital velocity and escape velocity are related as follows.

Orbital velocity, $v_o = \sqrt{Rg}$

Escape velocity $v_e = \sqrt{2Rg}$

Therefore $v_e = \sqrt{2}\ v_o$

Geostationary satellites

You are watching live cricket matches from around the globe, using internet, using GPS on mobile. Have you ever thought how this high technology communication possible at all!

These developments in the area of communication technology are possible because of the artificial satellites that are launched so that they remain in fixed positions relative to the earth, at a specific height above the equator. The period of revolution of the satellite is same as the period of rotation of the earth. This means that the satellite is always above the same spot on the earth. These are called as Geostationary Satellites. These satellites provide relay facilities for international communication.

Three satellites in proper positions can connect any part of the globe to any other part, establishing communication link across the world. The radius of the orbit of Geostationary satellite is 36,000km

Fig 24.15
Rakesh Sharma

The first Indian to fly into space, Rakesh Sharma was born on 13th January 1949 in Patiala, Punjab. He joined Indian Air Force in 1970 as a pilot officer after joining NDA as an I.A.F cadet in 1966. He flew aboard SOYUZ-7 as a part of intercosmos programme. The crew spent seven days aboard in SOYUZ-7 and conducted scientific and technical studies. Rakesh Sharma worked mainly in the field of biomedicine and remote sensing. Surprisingly his name refers to the moon. Raaka means moon light. Rakesha means moon.

Indian Space Programme

In the past five decades, India has many achievements to its credit in space. During this period, Indian space scientists have successfully built many types of satellites, They include communication satellites, meteorological (weather watching) satellites, remote sensing satellites, and scientific satellites. These satellites are providing many valuble services to India like telephone calls and internet data relay, helping to make accurate weather forecasts, accurate survey of the country's resources making travel safer, exploring space, and so on. Many of these satellites, have been launched from India it self ignited Rockets like Polar Satellite Launch Vehicle (PSLV) and the much bigger, heavier and more efficient Geosynchronous Satellite Launch Vehicle (GSLV). build by Indian Space Research Organisation (ISRO). In fact, PSLV has launched many foreign satellites in addition to the Indian ones. Very few countries have done this successfully.

With such important successes in Earth orbit, India became confident and in 2008 took a giant leap towards the moon. That year, ISRO sent Chandrayaan-1, an unmanned spacecraft to explore the moon, Earth's only natural satellite.

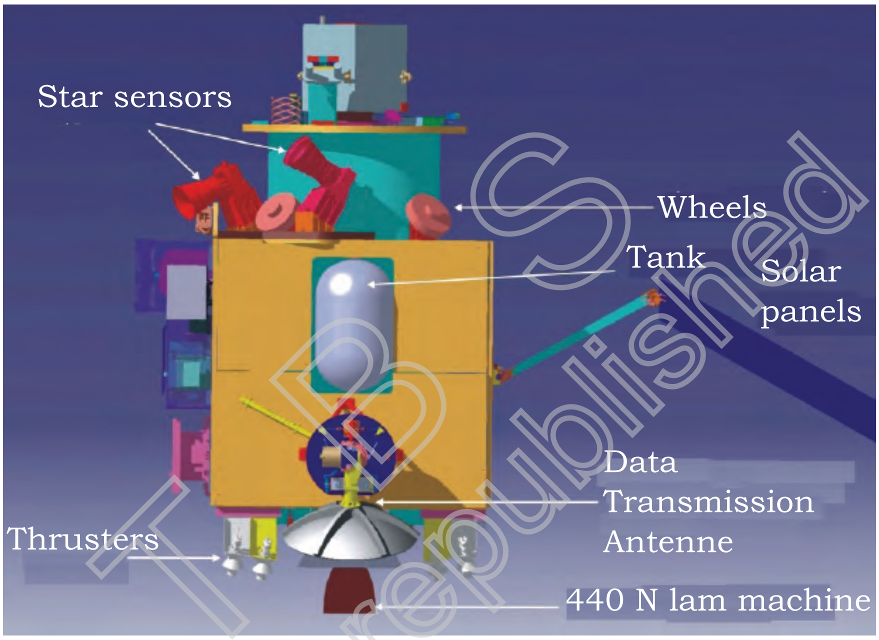

Fig 24.16 Chandrayaan

Chandrayaan-1: India's Greatest Achievement in space

Chandrayaan-1 had a definite set of goals

To further enhance the already acquired knowledge about the moon

To technologically advance further

To provide a challenging opportunity to young scientists of India to do research in new and exciting areas like the study of planets (indeed, moon is comparable in size to some of the planets).

Encouraged by this success and based on its experience during Chandrayaan-1, in November 2013, ISRO launched a spacecraft to explore planet Mars. Amongst the planets of our solar system, Mars resembles the Earth in many important respects.

ISRO has been successful in developing Cryogenic rocket engine. It lunched GSAT-14 using Geosynchronous Satellite launch Vehicle - Development 5 (GSLVD 5). India can hope to have manned mission to moon.

Major milestones of indian space programme

1	Formation of Indian National Committee for Space Research	October 1962
2	Launch of a Sounding Rocket from Thumba Equatorial Rocket Launching Station (TERLS) near Thiruvananthapuram	November 1963
3	First Launch of an indigenous Sounding Rocket from Thumba	November 1967
4	Formation of Indian Space Research Organisation (ISRO)	August 1969
5	Launch of India’s first artificial earth satellite ‘Aryabhata’	April 1975
6	Launch of India’s first experimental remote sensing atellite ‘Bhaskara 1’	June 1979
7	First successful launch of a satellite (Rohini) from the IndianSoil (by India’s SLV-3 rocket)	July 1980
8	Launch of India’s first experimental communication satellite APPLE	June 1981
9	Launch of India’s first operational Remote Sensing Satellite IRS-1A	March 1987
10	Launch of India’s first indigenously built multipurpose satellite INSAT-2A	July 1992
11	First successful launch of India’s Polar Satellite Launch Vehicle (PSLV)	October 1994
12	First successful launch of India’s Geosynchronous Satellite Launch Vehicle (GSLV)	April 2001
13	Launch of SRE-1, India’s first recoverable space capsule and its successful recovery twelve days later	January 2007
14	Launch of PSLV carrying 10 satellites (eight of them from other countries)	April 2008
15	Launch of Chandrayaan-1, India’s first unmanned spacecraft to Moon	October 2008
16	Successful entry of Chandrayaan-1 into an orbit around the Moon	November 2008

17	Successful Reaching of Chandrayaan-1's Moon Impact Probe to the lunar surface	November 2008
18	Announcement of the conclusive discovery of(extremely small amount of) water on the Moon's surface by Chandrayaan-1	September 2009
19	Launch PSLV carrying India's Mars Orbiter Spacecraft, aimed to travel to Mars, enter into an orbit around that planet and explore Mars	November 2013
20	Launch of GSLV carrying a cryogenic rocket stage built in India	January 2014

Exercise

I. Answer the following

1. Explain the principle of rockets.
2. Draw a neat diagram of single stage rocket and label the parts.
3. Define orbital velocity of a satellite.
4. What is meant by escape velocity? Write the relation between escape velocity and orbital velocity.
5. What are the factors that decide the value of escape velocity?
6. What are multistage rockets? What are their advantages?
7. Make a list of the uses of artificial satellites.
8. Write an essay on Indian space programme.

II. Four alternatives are given to each of the following incomplete statement / question. Choose the right answer

1. Fuel and oxidant are together called

    a) fuel mixture b) combustion mixture

    c) propellants d) propulsions.

2. In the expression $RV_{ex} = Ma$, R stands for
   - a) resistance
   - b) rate of fuel consumption
   - c) rate of change of velocity
   - d) rate of change of mass.

3. Communication satellites are also referred to as
   - a) polar satellites
   - b) geostationary satellites
   - c) launch vehicles
   - d) projectiles

4. The value of escape velocity on earth is
   - a) 11.2 kmS^{-1}
   - b) 11.2 kmS^{-2}
   - c) 10.2 mS^{-1}
   - d) 11.2 mS^{-2}

5. The first Indian built rocket was launched from
   - a) Bangalore
   - b) Sriharikota
   - c) Thumba
   - d) Trivandrum

III. Fill in the blanks with suitable words or phrases.

1. The ratio of payload mass to fuel mass is known as __________.
2. The scienctic instrument or the satellite which is carried by the rocket is called __________.
3. The substance that provides oxygen to burn the fuel is called __________.
4. The velocity of the body along circular path is called __________.
5. The first Indian satellite is __________.

IV. Match the following.

A	**B**
1. Orbital Velocity	a) $\frac{mv^2}{R+h}$
2. Escape Velocity	b) $\frac{1}{2}mv^2$
3. Centripetal force on satellite	c) $\sqrt{2Rg}$
	d) $\sqrt{\frac{GM}{R}}$